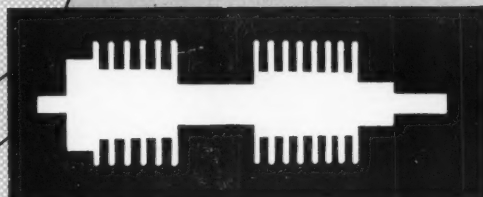


Design Engineering

MAY 8 1957

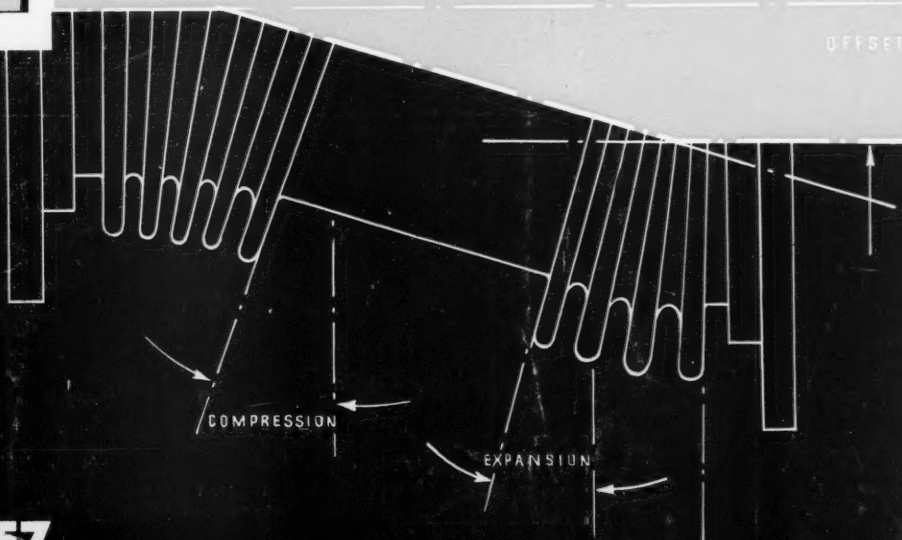
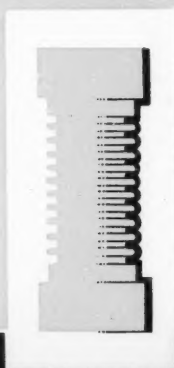
FIVE DOLLARS A YEAR



BELLOWS (p. 60)

Infrared ovens . . (p. 54)

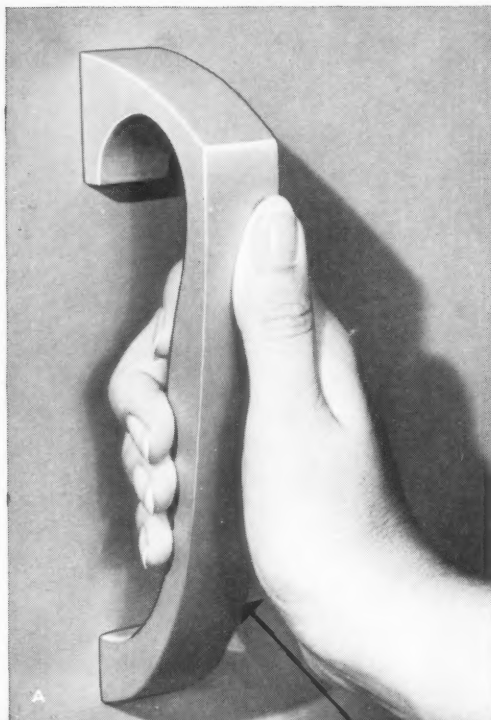
Refractories . . . (p. 49)



MAY 1957

PUBLISHED BY MACLEAN HUNTER PUBLISHING COMPANY, LIMITED, TORONTO, CANADA

Open the door to new freedom in design with ALCAN ALUMINUM EXTRUSIONS

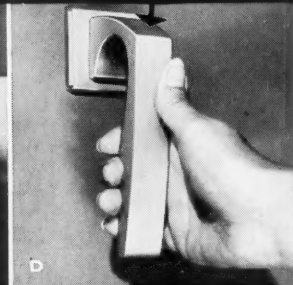
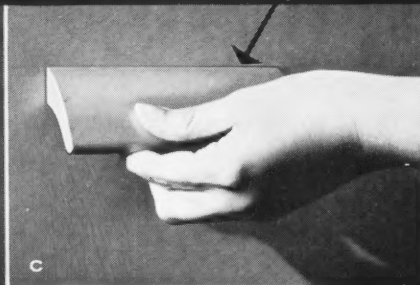
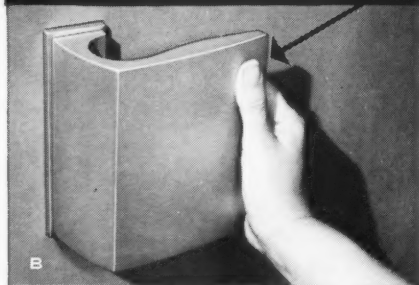
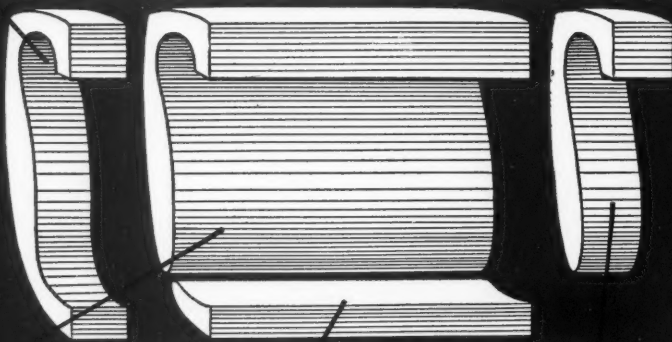


Offering a limitless variety of shapes and sizes, Alcan Aluminum Extrusions can help you improve your products and reduce costs.

Alcan aluminum extrusions have the uniformity and close tolerances that reduce assembly machining time. Labour, material and assembly costs are further cut because one-piece extrusions eliminate costly joining operations.

Alcan aluminum extrusions find a hundred and one applications in furniture, household appliances, machinery, motors, toys, and end products of all kinds. For full information on standard or special shapes to meet your requirements, call your Alcan Sales Office.

Here's a practical example* of the versatility of aluminum extrusions. 'A' - the basic one-piece extrusion cut to width for an attractive door pull. 'B' - the same extrusion modified and used in another width. 'C' - a section put to use as a drawer pull. 'D' - the modified version (B) cut to a thinner width for a lever handle.



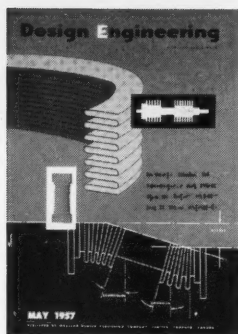
*Developed for Raymond Manufacturing Company by Alcan.

ALCAN

ALUMINUM COMPANY OF CANADA, LTD.

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DESIGN ENGINEERING MAY 1957



Design Engineering

VOL. 3

MAY 1957

NO. 5

This month's cover

As with last month, the May cover is the handiwork of Gerald Bern. Bern has chosen an unusual colour to put his artwork across and sets it off with an interesting use of reverse in the lower third of the page. He took our bellows article as his subject and, dominating the treatment is a cutaway section of the leaves of one such assembly.

Design Engineering

MEMBER

CCAB

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DESIGNERS' DELIGHT

Almost every design problem is a problem of materials. Is the price right . . . is it strong enough . . . light enough . . . colourful and bright enough? Can it be cheaply formed and produced at speed . . . is it resistant to corrosion, rust, denting or scratching?

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Design Engineering

Inside

William Morse

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In our next issue

Design Engineering's feature article in June will concern the ball resolver, a device that can evaluate two input values in terms of trigonometrical (or other) ratios.

We'll also carry articles on steam heat treating, powder metal parts, power steering, tap design and a review of some of the latest developments in silicone rubber.

George A. Remiz (Oven heating with rays we cannot see) is application engineer for component heating devices with CGE in Toronto. A graduate of the Technical University of Vienna, he worked for various Austrian electrical manufacturers, including spells as manager and district engineer in Egypt. Hobbies?—history and alpine plants.



REMIZ



SEWELL

Richard Sewell (This rig will test undercarriage performance) received his technical education in England during apprenticeship with British Thomson-Houston. He served in REME during the war and was an unwilling guest of the Japanese from 1942-45. He joined British Messier in 1947 and Dowty in Canada in 1955. He is now senior group head with Dowty.

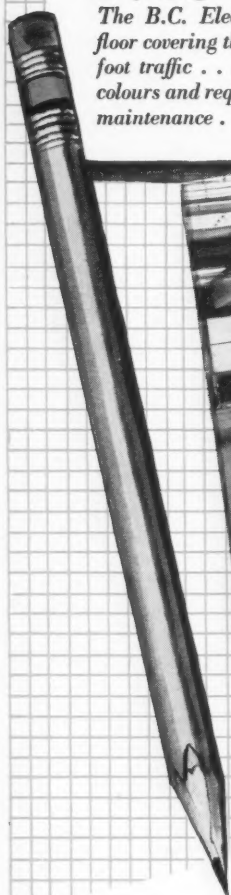


BROWN

Roy Brown (No metal resists such wear and heat) is a BSc in ceramic engineering from Rutgers and returned as a faculty member after 3 years in the U. S. army. He joined Carborundum in 1947 where he has held several positions. He is now manager of technical services. He has six children and still finds time to enjoy music and the theatre.

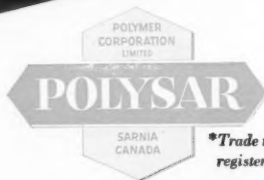
Problem

The B.C. Electric Company wanted a floor covering that would withstand heavy foot traffic . . . harmonize with interior colours and require a minimum of simple maintenance . . . for years to come.



Solution

Canadian General Tower Limited specified *Polysar Krylene NS for a custom-built, resilient "Peachglow" rubber tile because of its unsurpassed characteristics—initial light colour, colour stability, uniformity and ease of processing.



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Floor tile is just one example of how Polysar rubbers have been utilized by manufacturers to meet difficult, exacting specifications. Men of imagination in almost every industry have used Polysar rubbers to improve existing products and create new ones.

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Reports

News in brief from the world's producers

New polyethylene resin

The Bakelite Co., announces the availability of limited quantities of a higher density, high gloss, high melt index polyethylene resin for injection molding.

Because of the higher density of this resin, end products are improved in rigidity, permeability, heat and grease resistance. The molded pieces quickly reach the required rigidity for removal from the mold cavity, and faster cycles result.

Newcomer

Recent arrival on the Canadian scene is the firm of **Humphries & Glasgow (Canada) Ltd.** This is an all-Canadian company that was federally incorporated at the end of last year.

H. & G.'s activities cover the design, engineering and construction of all types of process plant and the company offers services to its Canadian clients in many fields, among them: economic studies, process design, engineering, estimating, procurements, construction and maintenance. These services cover primarily the field of petro-chemical, chemical, pulp and paper, textile, mining, gas and allied industries, but the company has in addition been entrusted with work for the aircraft and electrical industries.

The British pictorial magazine, the *Illustrated London News*, commented editorially in its March 9 issue on the parent firm as follows: "A British firm, Humphries & Glasgow Ltd., of London, recently acquired selling rights outside the North American Continent for small atomic power units of American design. These are for the production of electricity or heat and are similar to the power unit in the American atomic submarine Nautilus. A 10-megawatt station, sufficient for the needs of a town of 10,000 to 20,000 inhabitants, could be built on a space no larger than a tennis court. The new power stations are likely to prove particularly useful in remote and less developed areas."

Executive vice-president of the new Canadian company is Peter S. B. de Gray and vice-president, engineering, is C. Trevor Hawkes.

Hot box detective

The **Chesapeake & Ohio Railway** has set an infrared "Hot box detective" to sleuthing out one of the oldest railroad villains.

Detector units are located outside and parallel to the rails with infrared lenses angled up at 45 deg. at the axle journals

of moving railroad cars. The equipment records on tape the temperature of every journal box regardless of the train's speed.

A. V. Roe acquisition

P.S.C. Applied Research Ltd., one of Canada's leading designers and manufacturers of electro-mechanic instrument systems has been acquired by A. V. Roe Canada Ltd., from the Hunting group of Canadian aviation companies.

A Westinghouse first

The first aircraft electrical system in the world wired for automatic parallel operation of four engine-driven generators supplying high-voltage a-c power have been supplied to **Canadair Ltd.**, by the Canadian Westinghouse Co. The system will supply the power for radar, electronic and electrical equipment aboard the huge Canadair "Argus" being built by the Montreal aircraft firm for the RCAF Maritime Command. The four generators supply enough power to meet the requirements of 60 six-room homes completely equipped for electrical living.

Fellowship winners

The selection of **Athlone Fellows** for 1957 has now been completed. Twenty-nine Canadian engineers who will graduate this year and nine more who have spent some years in industry have been

selected from a considerable number of applicants for two years training in the United Kingdom. This training takes the form of two years in industry, or two years at a university or one year at each. The subjects which are to be studied include aeronautics, nuclear energy, metallurgy and civil, mechanical, electrical and chemical engineering.

Research department

A separate research department devoted exclusively to original research in automobile finishes has been established by the **Glidden Co.** in its Toronto plant. The new department will be the centre of research in this field for the entire Glidden organization in Canada and the United States. It will be headed by technical director Frank Steele, a graduate of the University of Saskatchewan, and Stuart Stanyon, a chemical engineer from the University of Toronto.

CGE helps education

A new plan to provide financial assistance for Canadian colleges and universities through direct grant of funds was announced in March by the Canadian General Electric Co. Ltd.

The new plan, known as the Corporate Alumnus Program, provides that the company will match dollar-for-dollar contributions made by CGE-employed alumni during 1957.

Jet limits?

The de Havilland Aircraft Co., says in London that it has reached the limit of conventional gas turbine jet engine developments with a model capable of 20,000-lb thrust.

The engine, the de Havilland Gyron 2, is designed to push planes along at



New York's Coliseum, venue of the Design Engineering Show. See p. 65.



Happy smiles at the University of Toronto. See "50,000 presented."

between 1,000 and 2,000 miles an hour at 50,000 ft. It packs more power than the giant engines which drive liner Queen Mary.

Approach lights

Flashing airport approach lights that pilots describe as resembling "a white hot football passed from pilot to runway" are now available from the **Canadian Westinghouse Co.**

Known as condenser discharge approach lights, the new units produce lightning-like flashes which cannot be mistaken for any other natural or artificial light that may be found in a heavily populated area. The duration of flash for each of the lights is only 150-millionth of a second. The entire line of lights flashes twice each second with the light farthest from the airport flashing first.

\$50,000 presented

Avro Aircraft Ltd., and **Orenda Engines Ltd.**, have jointly presented \$50,000 to the University of Toronto's Institute of

Aerophysics to help carry out a relocation and expansion program designed to meet the greatly increased demand for aeronautical engineers in Canada's aviation industry.

Other firms in the aviation industry are being approached with a view to raising the balance of \$100,000 which the Institute estimates it will need from industry to carry out its vitally needed relocation and expansion.

Seen in the picture on this page are, left to right: Dr. G. N. Patterson, director of the Institute of Aerophysics; Fred T. Smye, president and general manager of Avro Aircraft Ltd.; Dr. Sidney E. Smith, president of the University of Toronto; W. R. McLachlan, president and general manager of Orenda Engines Ltd.; and Dr. R. R. McLaughlin, Dean of the Faculty of Applied Science and Engineering. The group was photographed while examining a wind tunnel at the institute where a study is being made of the ram effect of jet engine intakes on aircraft flying at supersonic speed.

Next month in Design Engineering

JUNE

Ball resolver—Details of a mechanical calculator that can evaluate two input values in terms of trigonometrical (or other) ratios.

Silicone rubber—New uses for silicone rubber, made possible by recent developments.

Power steering—P. E. Biggar explains how it works.

Steam heat treating—How metalworking plants are making big savings in tempering, annealing and stress-relieving by using steam atmosphere heat treating.

Tap design—A review of the subject of tap design.

Powder metal parts—How to design and tool for their production.

Plus — More than 10 department pages

Trends

Colored sheet

Color anodizing by conventional processes has been too expensive for it to be used in some fields. This difficulty has now been overcome, however, by the introduction (by the Aluminum Co. of Canada, Ltd.) of coiled aluminum sheet, color anodized on one side only.

Known as Colorcoil, it will be produced in a variety of alloys in widths up to 48 in. and thicknesses from 0.020 to 0.064 in.

Hoist equipment

A line of Canadian-designed hoist equipment, covering a-c and d-c drives for drum or friction hoists, has recently been introduced by Canadian Westinghouse Co. Ltd. It is available with either manual or automatic push-button controls from the underground level.

Known as Selectalevel mine hoist control, the new (automatic) equipment can be applied to both skip and cage hoist drives.

Cast iron

Just published, a progress report on a research project dealing with the properties of cast iron at elevated temperatures (by J. R. Kattus, Southern Research Institute) sponsored by a joint ASTM-ASME committee.

Locomotives

To meet the growing demand for locomotives with a light axle load, General Motors Diesel Ltd. have developed the Flexicoil truck. This reduces the total truck weight and also provides a fully flexible truck for mainline and branch-line operations.

Polycarbonate

The discovery and initial development of a plastic material tough enough to replace metals in many applications was announced by General Electric Co. It is claimed that parts made from the new compound—it is known as Lexan polycarbonate resin—will stand up to blows from a hammer.

SAE papers

Recent SAE papers include: Developments in storage batteries (H. D. Wilson, Ford Motor Co.); Automotive engineering with urethane foams (R. A. Walsh, du Pont); New machining techniques made possible by electro-machining (C. Paul Porterfield, Firth Sterling Inc.); The application of oxide cutting tools (Edward Kibbitt, The Carborundum Co.); Wear resistant, low-cost sheet metal forming dies (J. C. Holzwarth and S. Menton, General Motors Corp.); Trends in modern aircraft structural design (E. H. Spaulding, Lockheed Aircraft Corp.).

WHICH of these Actuation Problems are YOURS?



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SPACE/WEIGHT



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TEMPERATURE



LUBRICATION



DEPENDABILITY

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AND PRODUCERS
OF MULTIPLE
CIRCUITS**

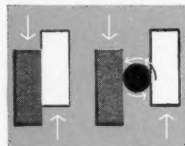


If one circuit should fail, the rest will function without interruption, sharing the load between them. In critical applications this feature has no equal.

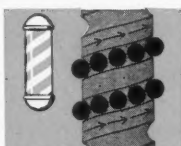
6 BASIC DESIGN ADVANTAGES

- 1. Vital Power Savings.** Permit much smaller motors with far less drain on electrical system, simpler circuitry.
- 2. Space/Weight Savings.** Screws themselves are smaller, lighter; permit smaller motors and gear boxes; eliminate auxiliary equipment required by hydraulics.
- 3. Precise Positioning.** Machine-ground type will position components far more precisely than hydraulics or pneumatics; tolerances on position are held within .0006 in./ft. of travel.
- 4. Temperature Tolerance.** Normal operating range from -75° to $+275^{\circ}$ F.; in selected materials, will function efficiently at temperatures as high as $+900^{\circ}$ F.
- 5. Lubrication Latitude.** If lube fails, will still function with remarkable efficiency. Units have been built and qualified for operation without lubrication.
- 6. Fail-Safe Performance.** Far less vulnerable than hydraulics; Gothic-arch grooves, yoke deflectors and multiple circuits provide added assurance against failure.

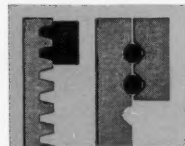
Here's why they're 90% efficient, save 4/5 on torque:



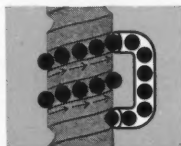
Let's start at the beginning, with the familiar principle that there's far less friction in rolling than in sliding. By applying this principle,



Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.



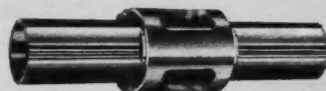
the Saginaw ball/bearing Screw radically increases the efficiency of rotary-to-linear motion (and vice versa). Instead of sliding, mating surfaces glide on rolling steel balls.



At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

Available in custom machine-ground and stock rolled-thread types. Units have been built from $1\frac{1}{2}$ inches to $39\frac{1}{2}$ feet long— $\frac{3}{8}$ to 10 inches in diameter.

SAGINAW b/b SPLINE



This revolutionary new kind of spline utilizes the same basic principle pioneered by Saginaw in the ball bearing screw.

It permits new engineering designs never before practical—literally lets you achieve the "impossible"! In any application where column length must change under torque load, the Saginaw b/b Spline offers greatly decreased friction, less wear, longer life, more dependable operation. It can be fitted with integral gears, clutch dogs, bearing and sprocket seats or a wide choice of other attachments for use with electric, hydraulic or pneumatic units. To convert push-pull to rotary motion, helical types are available with very high leads, ranging from 20:1 to 100:1.

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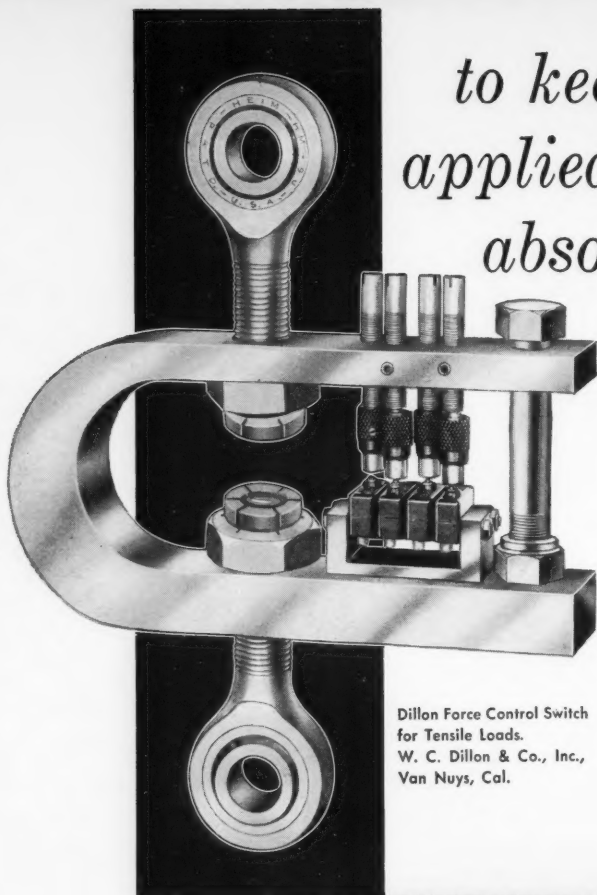
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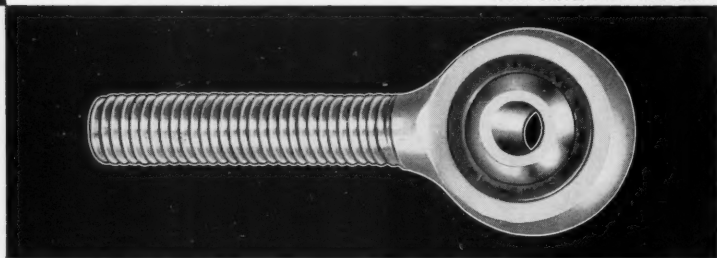
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applied line of force
absolutely vertical*



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for Tensile Loads.
W. C. Dillon & Co., Inc.,
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Heim Unibal Male Rod End



What does the Dillon Force Control Switch do?

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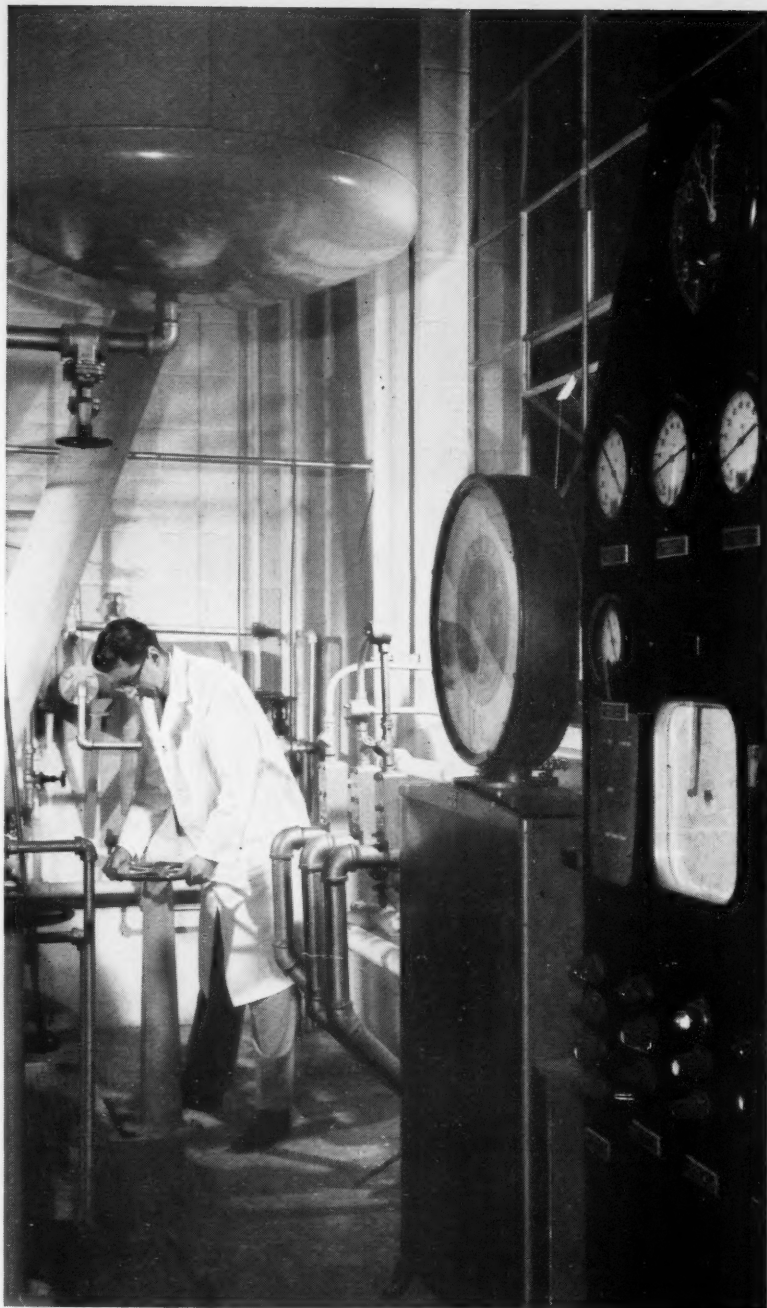
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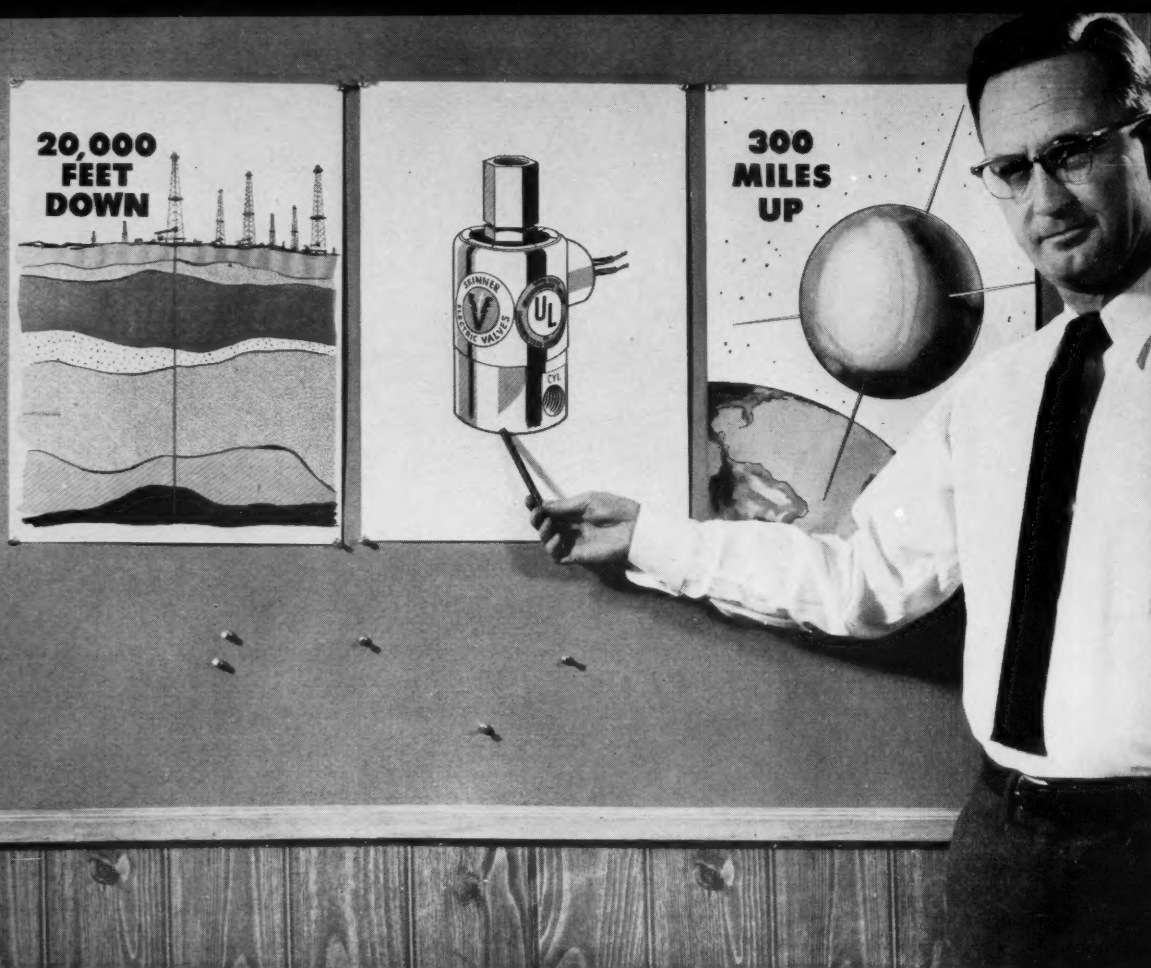
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The versatile design of Skinner Solenoid Valves makes their applications almost unlimited

Skinner Solenoid Valves have such great versatility that no one, not even their makers, knows the full extent of their applications. The range of their extremes demonstrates this vividly. One Skinner valve is being used in an instrument in Texas oil wells that tells the nature of earth strata 20,000 feet below the surface. Another one will be used to help launch the satellite that soon will be circling the globe.

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ceivably solve, we urge you to talk to a Skinner representative. Fill him in on the nature of your application. He'll be glad to work with you in selecting a valve that matches your requirements as to port sizes and locations, voltages, pressures, temperature conditions, flow adjustments and mountings.

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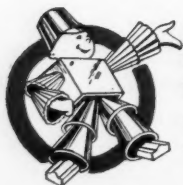


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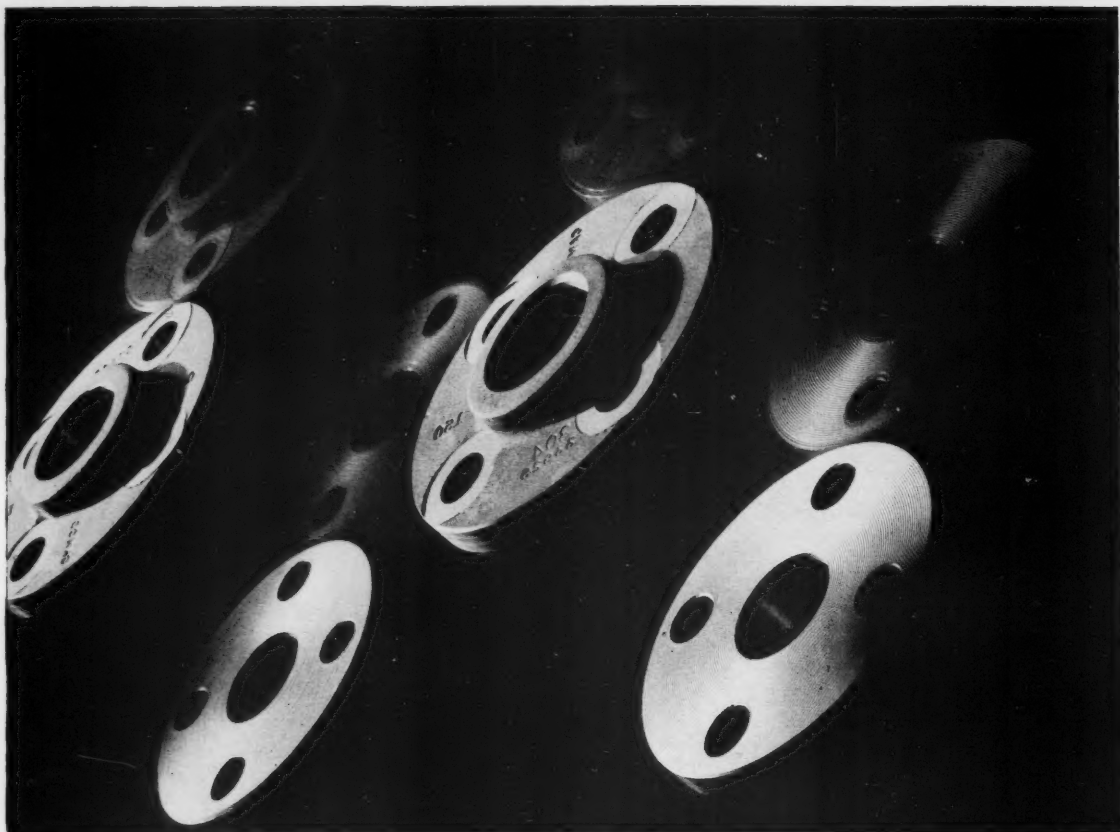
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PRODUCT ENGINEERING

PROPERTY AND APPLICATION DATA ON THESE
VERSATILE ENGINEERING MATERIALS: "ZYTEL,"
"ALATHON," "TEFLON," "LUCITE."

NEWS

New Canadian Plant now producing "ZYTEL" nylon resin

A new concept in plastics utilization is "home-grown" for Canadian industry.

The days of "plastic substitutes" have passed into history. The possibility of precise mechanical design using a plastic material is now a reality — thanks to 20 years of research and testing by Du Pont.

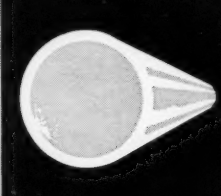
It took a remarkable material, "Zytel" nylon resin, to make the effort worthwhile.

"Zytel" nylon, plus good design and competent fabrication offers many cost-saving possibilities. These are brought about through lower initial costs and better performance of many mechanical parts in machines, hardware, appliances — even in notions, novelties and housewares. These possibilities should be of considerable importance to Canadian manufacturers faced with finding lower costs and better merchandise to meet the stiff competition of today.

Because of this, Du Pont Company of Canada (1956) Limited has installed and is operating a plant at Kingston, Ontario to make this useful material for the Canadian market.

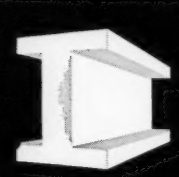
Actually, we do more than just make the resin. We also extend assistance to engineers and

$$t_{\text{(wall thickness)}} = \frac{PD}{2S} \left(S = \frac{2000 \text{ psi}}{\text{safety factor } = 4} \right)$$




"ZYTEL" - The Versatile Answer to Many Engineering Problems

$$Y_{\text{(deflection)}} = \frac{Fl^3}{48I} \left(E = \frac{90,000}{\text{apparent modulus}} \right)$$



$$HP_{\text{(horse power)}} = \frac{F \cdot Y}{P} \left(\begin{aligned} &= 2300 \text{ qt PLV} \\ &= 1000 \text{ ft/Min.} \\ &= \frac{150}{2000} \text{ PLV} + 0.25 \end{aligned} \right)$$



designers, to help them utilize the properties of "Zytel" to advantage, and of course, we assist molders in establishing optimum operating conditions required to faithfully reproduce the properties of the material in finished parts. In short, we provide a touch of creative imagination backed by sound technical knowledge along with a product of proven value.

On the following pages are illustrations of a few of the thousands of uses in which "Zytel" nylon has created new standards of value. There are several well-qualified Canadian molders who can help you to get these new values for your product. Why not let them — and us — have a chance to see what we can do for you?



PRODUCT ENGINEERING



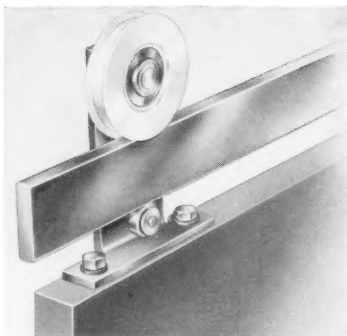
PROPERTY AND
APPLICATION DATA
ON DU PONT
"ZYTEL" NYLON RESIN

NEWS

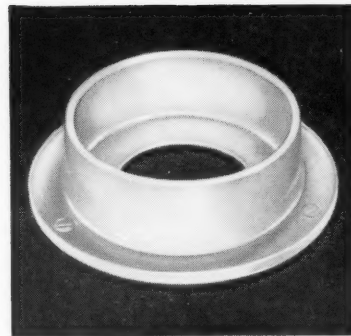
18 product



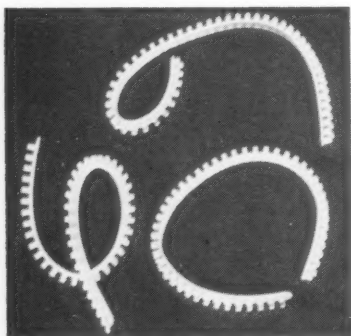
These counter wheels are molded in two different colors from ZYTEL. Light in weight, ZYTEL enables faster movement of the wheels with less power and a minimum of noise. (Manufactured by Electric Manufacturing Co., Inc., San Francisco, California.)



Hangers for horizontal sliding elevator doors require a high degree of rugged construction combined with extreme operating ease. The "ZYTEL" nylon molding for these wheels was done for Turnbull Elevator by Toronto Plastics Limited, Toronto, Ontario.



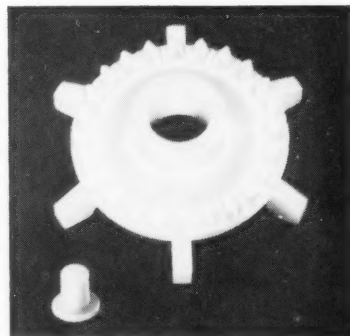
Simple nylon molding gives better seal, longer life and simplifies assembly of famous "Wix" oil filter cartridges. Required to remain tight at temperatures ranging from 50 below zero to 200 above, these seals were molded by Smith and Stone Limited, Toronto 5, Ontario.



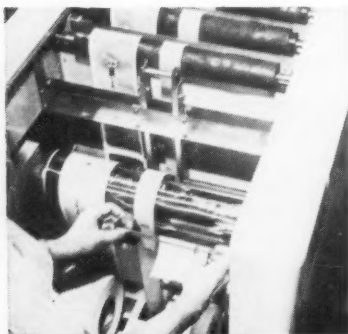
Grommets of ZYTEL are flexible and strong in thin sections—protect wire insulation from chafing in eyelets of any size or contour. These grommets are quickly cut and fitted from a 10-inch "Caterpillar" strip. (Manufactured by Nylon Molding Corporation, Garwood, N. J.)



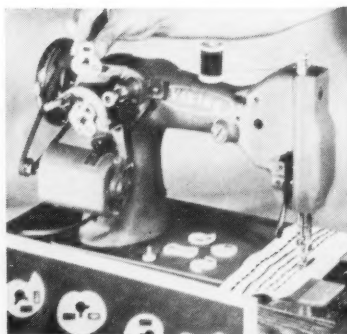
Cable stringing block is equipped with spools of ZYTEL which are abrasion-resistant and tough—will not damage cables. (Processed by Engineered Products, Inc., Kirkwood, Missouri for D. H. S. Company, St. Louis 17, Missouri.)



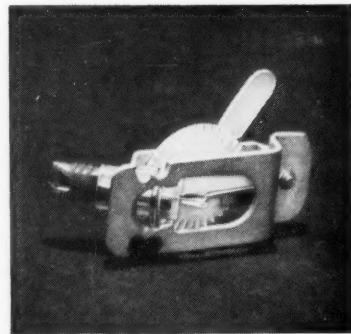
Oil slinger gear of wear-resistant ZYTEL operates quietly and withstands high temperatures inside an air-cooled engine. Stop switch button of ZYTEL stays cool even when engine is at 200° F. (Molded for Briggs and Stratton Corp., by Sinko Mfg. & Tool Co., Chicago.)



The belting of this photo processing machine is made of ZYTEL—is unaffected by developing and cleaning solutions. ZYTEL has high tensile strength, even in thin sections, and is resilient and flexible. (Belting produced by The Polymer Corporation of Pennsylvania, Reading, Pennsylvania.)

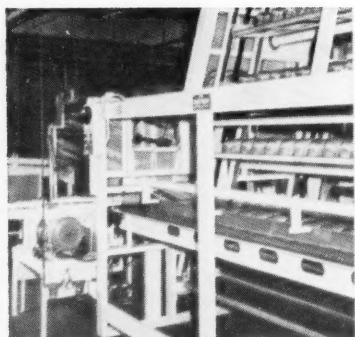


Interchangeable cams of ZYTEL in this sewing machine provide variations in stitching patterns. ZYTEL simplifies production, lowers costs due to ease of molding. (Molded by Boonton Molding Company, Boonton, New Jersey, for Consolidated Sewing Machine Corporation, New York, New York.)

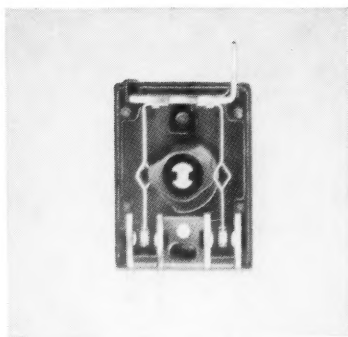


Phonograph needle holder of ZYTEL is molded into intricate shape and holds switching mechanism for different speed needles. Important in this application are the good dielectric properties and toughness of ZYTEL. (Phonograph needle holder manufactured by Electro-Voice, Buchanan, Michigan.)

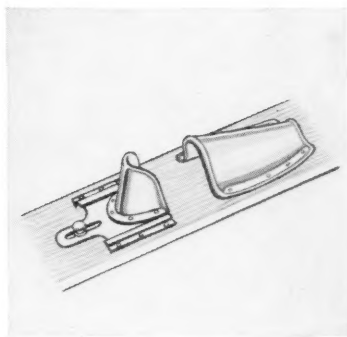
examples of improved design with ZYTEL nylon resin



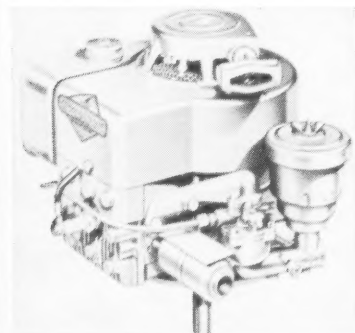
The rollers of this bread cooling equipment are manufactured under the Sanitation Code. Over-all performance of ZYTEL is found superior to that of metal. (Molded by United Plastics Industries Inc., Vassar, Michigan, for Baker Perkins Inc., Saginaw, Michigan.)



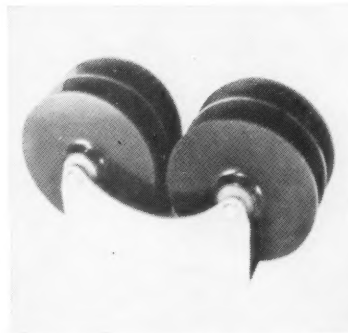
The cams which control the indexing of this rotary switch are made of ZYTEL. Because of its durability and strength qualities, ZYTEL replaced another material. (Molded for Cutler-Hammer Inc., by Sinko Mfg. & Tool Co., Chicago, Illinois.)



The "Brydon Boy" B-110 ski harness uses "ZYTEL" nylon clips where the maximum stress is experienced in water skiing. Replacing aluminum stampings formerly used to anchor the soft, flexible toe and heel pieces, these "clips" were molded for Brydon Brass Mfg. Co. Ltd. of Toronto by Toronto Plastics Limited, Toronto.



The bumpers for the starter pulley of this engine are made of ZYTEL, are adaptable to mass production. Quiet operation and longer wear result, because ZYTEL requires little or no lubrication. (Engine produced by Briggs and Stratton Corporation, Milwaukee, Wis.)



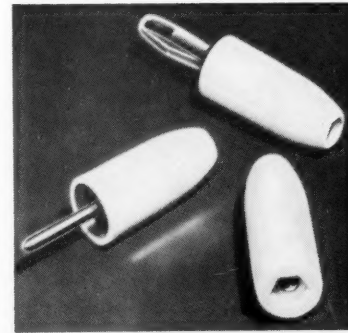
Bushings in a new sealed journal box kit are made from ZYTEL. Important in this railroading advancement is the ability of ZYTEL to withstand extremes in temperature. (Manufactured by National Motor Bearing Company, Inc., Redwood City, California.)



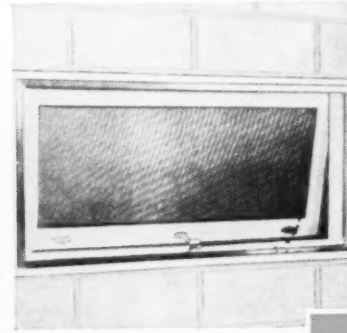
The gears, bearings and blades of this mixer are made of ZYTEL because it is light in weight and resistant to heat, wear and corrosion. The Maynard Manufacturing Company of Glendale, California, expects these parts made of ZYTEL to outlast useful mixer life.



This pneumatic sump pump, run by air pressure, contains four vanes of ZYTEL. Driven at high speeds, the vanes are resistant to wear and are molded to extremely close tolerances. (Molded by Ingwersen Manufacturing Co., Inc., Denver, Colorado, for Gardner-Denver Company, Denver, Colorado.)



Tip jacks of ZYTEL have high dielectric strength, resist heat, cold and moisture, and stand up to high voltages under rugged operating conditions. Threaded insulating sleeve of ZYTEL with standard tip jack provides superior connector. (Manufactured by E. F. Johnson Company, Waseca, Minnesota.)



The latch on this window assures long-time service, because of the toughness, abrasion-resistance and high-impact strength of ZYTEL. (Molded by DuBois Plastic Products, Inc., Buffalo, N.Y., for Curtis Companies, Inc., Clinton, Iowa.)

OVER



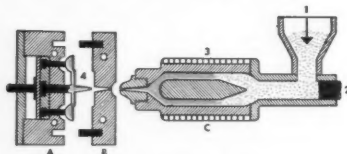
PRODUCT ENGINEERING

PROPERTY AND APPLICATION DATA ON THESE
VERSATILE ENGINEERING MATERIALS: "ZYTEL,"
"ALATHON," "TEFLON," "LUCITE."

NEWS

Injection molding process is rapid production method

INJECTION molding is one process for producing large quantities of plastic parts. A typical injection-molding assembly, shown in the diagram, operates as follows:



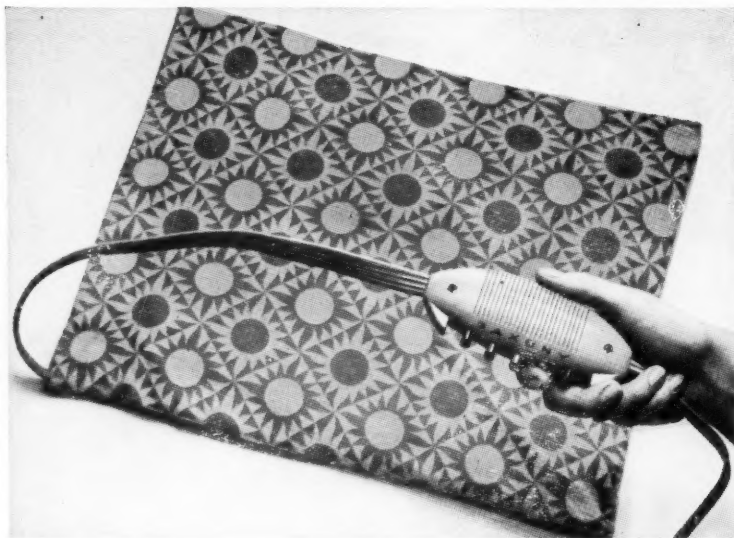
Parts marked *A* and *B* close and lock to form the *mold*; they move to contact part *C*, which contains molten plastic. Measured quantities of the granulated plastic (*1*) are fed into the machine. The reciprocating *ram* (*2*) forces this material into the *heating chamber* (*3*), where the powder liquefies. Each forward motion of the ram (*2*) forces molten plastic into the closed mold (*A* plus *B*), where the plastic solidifies and forms the *molded part* (*4*). Then the mold opens as shown in the diagram and the plastic part is ejected. In the meantime, the ram moves back, allowing more powder to feed into the machine, preparing it for another molding cycle.

The production rate depends on a number of variables, including the size of the part and the number of identical cavities cut into the mold. If molded parts are small, dozens of them can be made at one shot, whereas large parts may be produced one at a time. Cycles of 1 or 2 moldings a minute are not uncommon.

Here are some of the advantages of injection molding:

1. High rate of production
2. Economical production in quantity
3. Little or no finishing cost
4. Parts molded to close tolerances.

Economical and durable control switch made with ZYTEL* nylon resin



The durability and impact resistance of ZYTEL permit reduced costs in the Saxony switch, because less wall thickness is required. The multiple

switch controls the temperature of electric heating pads and is molded by Wilmington Plastics, Wilmington, Del., for Saxony Electronics of Wilmington.

FUNCTION and appearance, coupled with cost, are important factors in the design of a new product. Because of this, the Saxony multiple switch, which controls the temperature of electric heating pads, is molded of ZYTEL.

ZYTEL was chosen for the Saxony switch because of its durability and impact strength, even in thin sections. The thinner walls of ZYTEL result in economy of material, and a reduction in costs.

Its low coefficient of friction gives ZYTEL excellent bearing characteristics.

For this reason, the moving parts of the switch are also molded of ZYTEL nylon resin.

Available in white and in a wide range of colors, ZYTEL nylon resin permits a variety of design possibilities. Readily molded to close tolerances, ZYTEL is an excellent material for applications such as the Saxony switch.

For complete information on this versatile material—property tables, typical applications, and production techniques—simply clip and mail this coupon.

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DE-5

Please send me more information on the Du Pont plastic engineering materials checked: ☐ "Zytel"; ☐ "Alathon"; ☐ "Teflon"; ☐ "Lucite". I am interested in evaluating these materials for

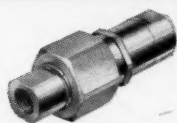
NAME _____ POSITION _____
COMPANY _____
STREET _____
CITY _____ PROVINCE _____
TYPE OF BUSINESS _____

*"Alathon", "Lucite", "Teflon" and "Zytel" are registered trade-marks of E. I. du Pont de Nemours & Co. (Inc.)

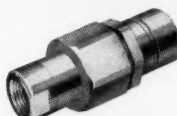
NEED MORE INFORMATION?

Clip the coupon for additional data on the properties and applications of this versatile Du Pont engineering material.

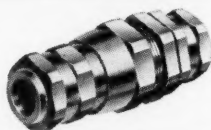
How Aeroquip Self-Sealing Couplings Simplify Connection and Disconnection of Fluid Lines



Industrial Type 5100 (wing union nut) or 5110 (hex union nut) for hydraulic fuel, oil, air and water lines.



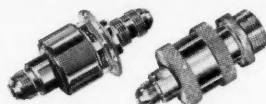
Farm Type 5203 for hydraulic lines from tractor to farm implements.



Freon Type 5400 for precharging air conditioning lines and components at the factory.



LP-Gas Type 5104 for quick recharging of LP-Gas fuel tanks.



Aircraft Type 145-135 and 3200 for all airframe and engine oil, fuel, hydraulic, and pneumatic lines.



Railroad Type 510022 for quick, safe refueling of diesel locomotives.



Soap testing for leaks is speeded up by using an Aeroquip Self-Sealing Coupling to connect a 240 psi air line to a joint.

Fluid systems requiring frequent disconnection and reconnection can be improved and simplified with Aeroquip Self-Sealing Couplings. One Self-Sealing Coupling performs the same function as two shut-off valves. It occupies less space and speeds fluid line connection and disconnection.

All Aeroquip Self-Sealing Couplings have the following basic characteristics:

- Quick, easy connection and disconnection of pressurized fluid lines, without loss of fluid or inclusion of air or foreign matter into the system.
- Full fluid flow through connected coupling; leak-proof sealing of disconnected coupling halves under maximum line pressure.
- Positive locking action on connection to prevent accidental coupling disconnection and flow shut off.
- Simple, sturdy design, with sufficient valve strength for long, trouble-free operation.

Poppet-Tubular Valve Design

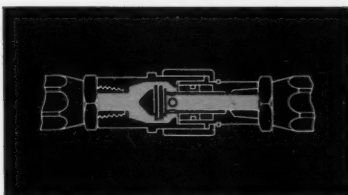
Every Aeroquip Self-Sealing Coupling is designed around mating, spring-loaded poppet and tubular valves. This design principle combines positive sealing action with optimum flow characteristics.

In operation, the poppet valve coupling half mates with the tubular valve coupling half, joined by a quick-threading union nut. Valves open and

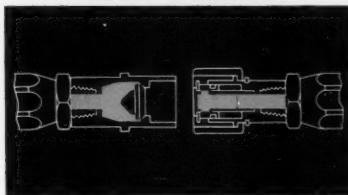
close simultaneously with the locking and unlocking action of the union nut. Once connected and locked, the coupling cannot unlock accidentally due to vibration and other external forces. Fluid flow through the connected coupling is accomplished with maximum safety and minimum pressure drop.

Many Types Available

No single type Self-Sealing Coupling is ideally suited for the wide range of industrial, aircraft, marine and farm applications. Aeroquip presently manufactures seven types (shown at left) to meet the requirements of varied fluid system use.



Connected coupling—
full flow at any pressure.



Disconnected coupling—
halves seal at any pressure.

Full information is available. Fill in and mail the coupon below for your copy of "The Case of the Self-Sealing Coupling" plus engineering bulletins on the coupling types to fit your fluid system needs. See our catalog pages in Sweet's Product Design File, Section 6d.



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Toronto 10, Ontario

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| <input type="checkbox"/> AEB-14 on Aircraft type | <input type="checkbox"/> IEB-1 on Railroad Diesel Fueling type |
| <input type="checkbox"/> IEB-10 on Freon type | <input type="checkbox"/> Bul. 165 on Farm type |

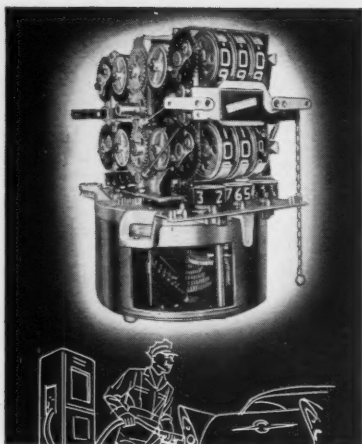
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Title _____

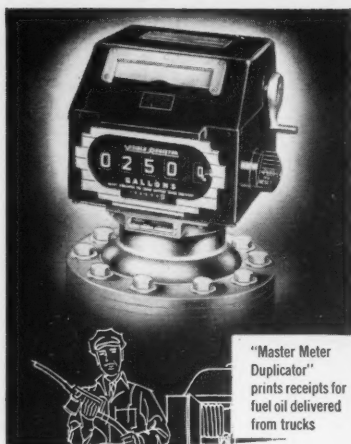
Company _____

City _____ Zone _____

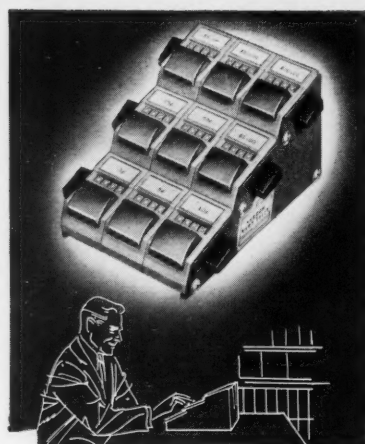
Prov. _____



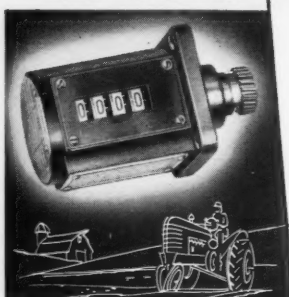
Computing Head for Gasoline Pumps



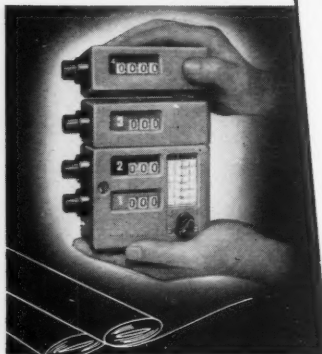
"Master Meter Duplicator" prints receipts for fuel oil delivered from trucks



"Vary-Tally" Multi-Unit Reset Manual Counter



Rev-Counter for all types of engines

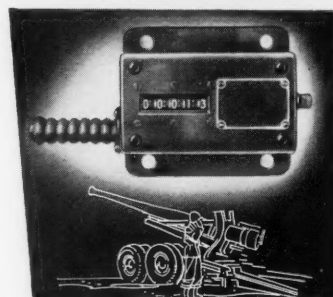


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Everyone Can Count on VEEDER-ROOT

Everywhere you look in everyday life, you see a familiar face . . . the face of a Veeder-Root Counter or Computer. From gasoline pumps to fuel oil trucks to textile mills . . . in the home, on the farm, in business and commerce, in modern automated industry . . . Veeder-Root standard and special devices are keeping everything under *Countrol* . . . manually, mechanically, electrically. And the mathematical probabilities are mighty high that you can count on Veeder-Root, too . . . to your advantage and profit. Why not let us figure out how, right now?

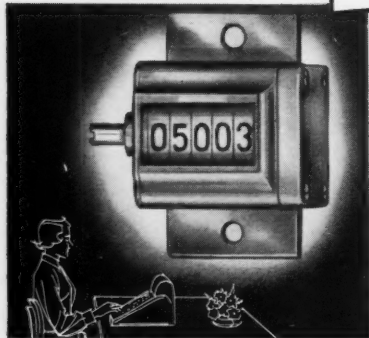
VEEDER-ROOT OF CANADA LIMITED
955 St. James St., Montreal



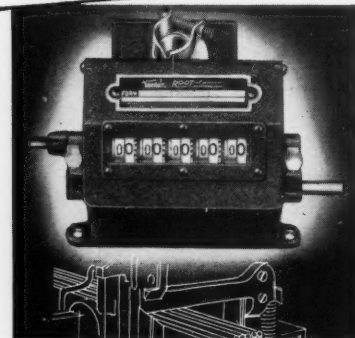
Recoil Counter for new 280 mm atomic cannon



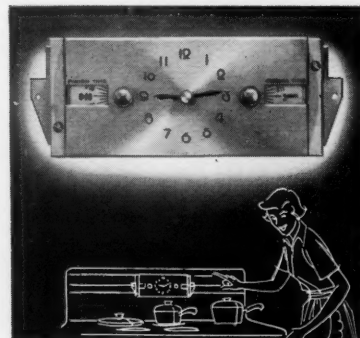
Fuel-Remaining Counter for aircraft . . . subtracts as fuel is used



Small Square-Case Counters for office and other machines



Predetermining Counters for preventing short and over-runs on production machines

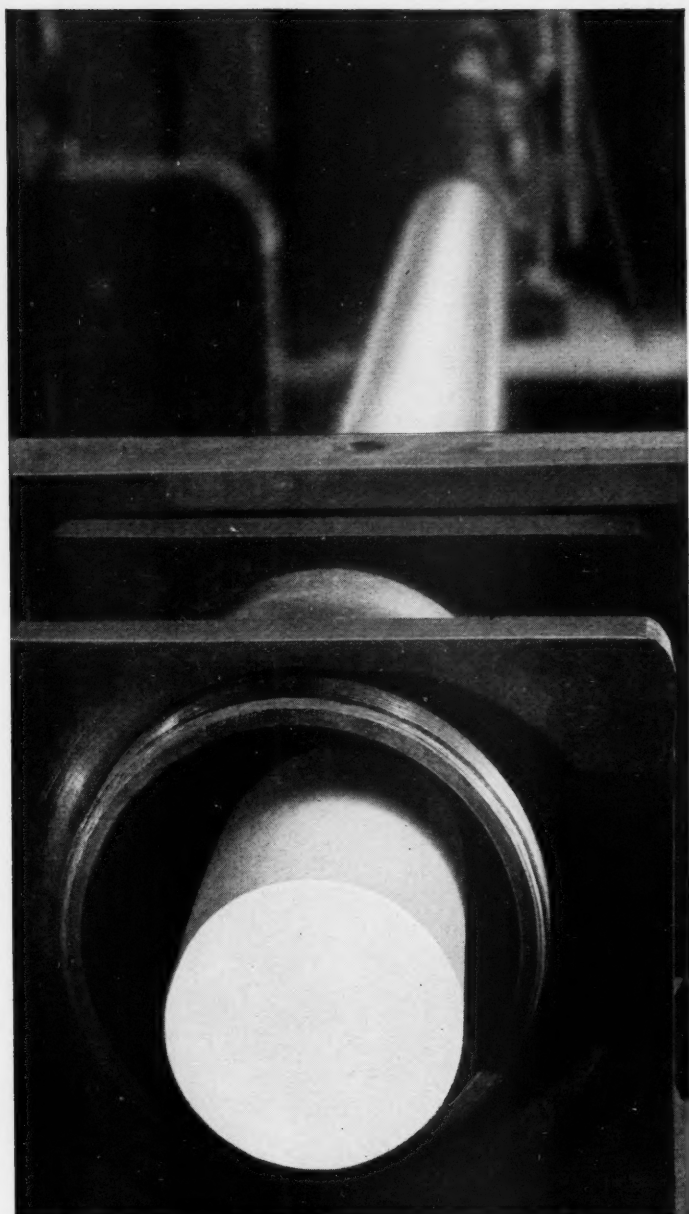


Range Timer . . . easy to read . . . easy to set

Main Office and Factory: Veeder-Root Inc., Hartford 2, Conn., U.S.A. • Offices and Agents in Principal Cities

"The Name That Counts"

THE NATIONAL SCENE



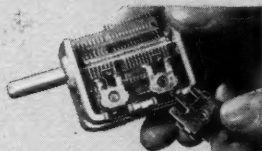
FAMOUS NYLON JOINS NATIONAL'S MATERIALS FAMILY. Proved in thousands of tough applications, versatile Nylon now becomes more useful to the designer than ever. National makes it so in extruded rods and 100% usable finished fabricated parts. Standard rod sizes range from $\frac{1}{4}$ " through 2" in 3 and 6-foot lengths. Inquiries on other sizes and shapes are invited. National's expert engineering counsel assures the commercial soundness and economy of your product. And men, machines and capacity place National in a unique position to serve your immediate needs.

NATIONAL CAN HELP YOU reduce unit product cost or improve product performance at no added cost. Here's why: You can select the "one best material" from over 100 grades of PHENOLITE®, Vulcanized Fibre and NATIONAL Nylon—without compromise in properties or cost. You can simplify production and purchas-

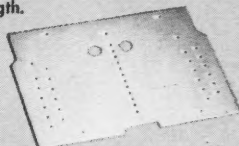
ing with the *timed delivery* of 100% usable parts—from a *single reliable source*. You gain competitively with National's new materials and grades—the *direct results of programmed materials-research*.

You benefit by calling National first. Check telephone directory yellow pages or write Toronto—Dept. N.

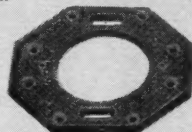
INTRODUCING 5 NEW superior PHENOLITE® Laminated Plastic Grades:



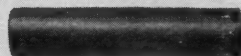
E-2040—A new low cold flow, hot punching paper base grade with good dielectric strength.



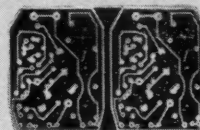
Y-2500—A good arc resistant paper base grade with excellent flame resistance plus superior punching and shaving characteristics.



G-8-881—A melamine bonded glass mat grade with excellent flame and arc resistant characteristics and good flexural and impact strength. Has high dimensional stability under humid conditions.



G-7-3604—A new thick-walled silicone fiber glass tubing material with exceptional heat resistance and electrical properties.



G-10-865—A new epoxy resin-bonded glass cloth sheet laminate with very low water absorption and excellent electrical properties.

THESE FIVE NEW PHENOLITE GRADES bring to over 80 the number of standard and special grades of this versatile laminated plastic.



NATIONAL

FIBRE COMPANY OF CANADA, LTD.
ATLANTIC & HANNA AVENUES, TORONTO
1411 CRESCENT STREET, MONTREAL



NORANDA COPPER AND BRASS LIMITED

COPPER ALLOY BULLETIN



MILLS AT MONTREAL EAST—OFFICES IN MONTREAL, TORONTO, VANCOUVER, EDMONTON
Export Department, P. O. Box 1238 Place D'Armes, Montreal, P. Q., Canada



High-quality, precision-made screw machine items. Courtesy Y. W. Small Parts Ltd., Toronto 5, Ontario

Building up a Reputation for Quality Screw Machine Items

Why are some screw machine shops consistently busy at all times while others depend on peak periods of industrial activity for their very existence? The answer as to what makes a successful shop tick may well be strict quality control backed up by dependable service.

How can a screw machine shop obtain the needed quality-plus service for successful operation?

Most screw machine items are made on a contract basis to customers' specifications. Since they are intended to go into some special assemblies, they must be uniformly accurate and close in tolerances otherwise they can easily give endless trouble. The smaller the item, the more need for exactness.

Every screw machine operator knows that consistent quality demands good equipment and tools. Machines must be put into tiptop condition and maintained that way. He is aware that tools must be given careful attention for proper grinding and sharpness. For long runs, and heavy removal of stock, he must go to carbide tools for highest efficiency.

Good Labor Relations Essential

Management can achieve the objec-

tive of quality and service so necessary for the business success of a screw machine shop whose operation calls for skilled workers that are dependable and self-sufficient. A good operator uses his own judgment as to the state of his tools and accuracy of his production. Close watch and periodic gauging of his production are absolutely essential.

The development of a high-type operator takes long, patient years as well as a considerable investment in money. Good management, therefore, makes every effort to establish good labor relations which will result in the minimum of labor turnover. To achieve this, the management gives the worker pleasant surroundings and considerate treatment. Naturally, he must receive steady employment and suitable compensation for his efforts. High quality and good service are premiums which are in great demand by users of metal products, and repeat orders as well as new business results.

Alloy Selection Important

The choice of metal or alloy rod is important especially for the manufacture of difficult items or those that must stand severe usage. Management

must have an open mind and be willing to look into and try out different alloys and tempers.

Copper-base alloys for screw machine operation are numerous and varied. For most jobs Noranda free-turning brass rod (approximately 61% copper, 3.4% lead, remainder zinc) is highly satisfactory. It is exceptionally free machining and gives off fine chips. Its composition is uniform and dimensions are accurate. Tool wear is minimized, yet, under certain conditions where deep knurling or cold-working is necessary, a soft temper may be more suitable. Or an alloy with less lead such as Noranda free-turning brass rod, medium leaded, (approximately 63% copper, 1.8% lead, remainder zinc) should be used.

An inquiry as to the customer's application of the screw machine part may lead to the recommendation of a superior metal. For example, if high electrical or thermal conductivity is called for, Noranda Tellurium Copper (approximately 99.5% copper, 0.5% tellurium) should be considered. It tins more readily than other metals and is less subject to oxidation. It has a machinability rating of 90% as compared to 20% for electrolytic copper which has been used for high conductivity applications.

Naval brass 24 (approximately 60% copper, 0.65% tin, remainder zinc) is specified for making marine hardware, screws, bolts and nuts. It has a machinability of 30%. Naval brass can also be supplied with 1.75% lead (Alloy No. 29) and as low as 0.6% lead (Alloy No. 28). The addition of lead does not affect its corrosion resistance but improves its machinability.

Where great strength, hardness and excellent corrosion resistance are needed, Noranda Aluminum Bronze (approximately 91% copper, 7% aluminum, 2% silicon) should be considered. It has a machinability rating of 60% as compared to free-turning brass. Aluminum Bronze can also be used for pump parts for corrosive waters and for the manufacture of valve stems.

Noranda's metallurgical laboratory will be glad to assist manufacturers by helping them to select the alloys best suited for specific applications. (4357)

SHAWINIGAN

PERMA-SPUN^{*}

CENTRIFUGALLY CAST STAINLESS STEEL

YIELDS A SUPERIOR CASTING! OFFERS ADDED ECONOMIES!

In the production of cylindrical shapes, and for small castings of irregular shape, the *Centrifugal Casting Method* yields a quality product much superior to that produced as a static casting.

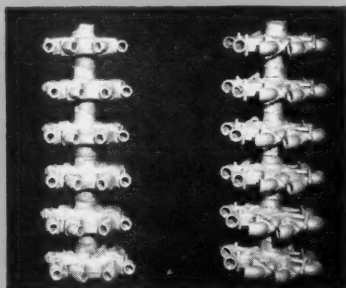
And Shawinigan PERMA-SPUN offers significant economies over drawn tubing. Even on small quantities of any

specific analysis the cost is low, and on large runs permanent molds can be used permitting a thinner wall and less machining allowance.

Centrifugal Force ensures complete freedom from non-metallic inclusions and shrinkage and creates a dense, fine-grained casting with enhanced physical properties.



Centrifugally cast CF10M pipe for sulfite acid circulation systems.



Centrifugally cast stacks of CF8 fittings (as cast condition).



Centrifugally cast HU retorts for magnesium production.

Illustrated are a few of the many applications of *PERMA-SPUN* corrosion and heat-resistant stainless steel. Consider the possibility of saving money in your operations with "Shawinigan" *PERMA-SPUN* centrifugally cast Stainless Steel!

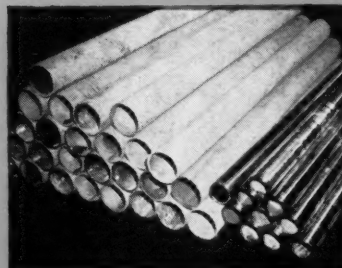
**Registered Trade Mark*



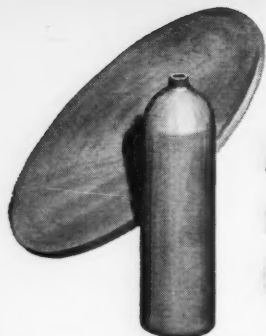
SHAWINIGAN CHEMICALS LIMITED
STAINLESS STEEL AND ALLOYS DIVISION

Shawinigan Building, Montreal

220 Eglinton Avenue East, Toronto



Centrifugally cast radiant tubes and rolls for heat treating furnace — cast in permanent molds.



Flat Blanks to Finished Cylinders...

Higher Production Better Quality

one of the nation's
foremost producers of cylinders
for compressed gases
—NORRIS-THERMADOR CORP.—
uses Parker's aids to cold forming

The Bonderite and Bonderlube combination provides effective lubrication and acts as a non-metallic parting layer between work and dies. More severe deformations are possible, reducing the number of press operations and process anneals necessary. Die life is lengthened and surface finish improved.

Bonderite and Bonderlube, by more efficient lubrication, help plants reach new production levels, get more efficient and economical production, and achieve better, more uniform quality.

Parker's cold forming experience in many plants and on many products is available to apply on your cold forming problems at once. Write or call today.



PARKER

RUST PROOF COMPANY OF CANADA, LTD.

Rexdale Blvd., Rexdale (Toronto), Ontario

BONDERITE
corrosion resistant
paint base

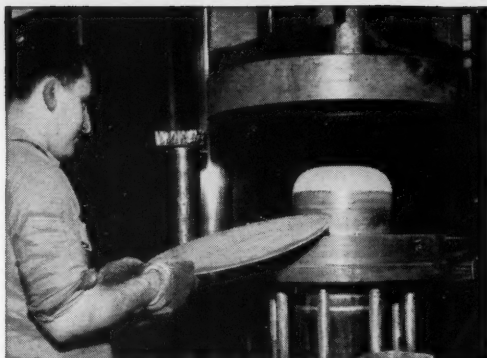
BONDERITE and BONDERLUBE
aids in cold forming
of metals

PARCO COMPOUND
rust resistant

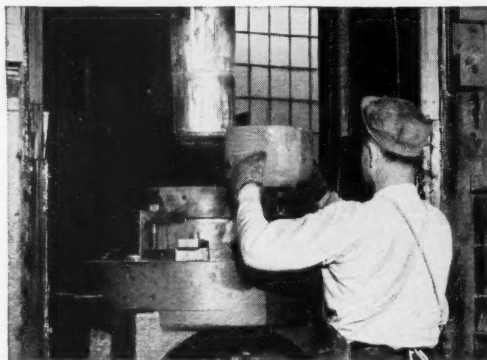
PARCO LUBRITE
wear resistant for friction
surfaces

TROPICAL
heavy duty maintenance
paints since 1883

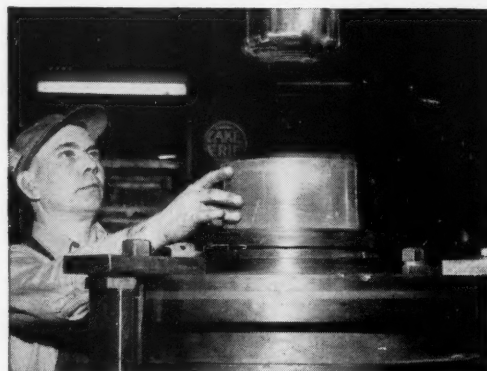
*Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U.S. Pat. Off.



Cupping: Flat CO₂ cylinder blank, treated with Bonderite and Bonderlube, is changed into cylindrical form, with maximum of about 45% reduction in diameter of blank.



First reduction: Diameter of cup is made smaller and length increased without major change in wall thickness.



Second reduction: Final diameter of part with respect to length determines number of reductions required. Photos courtesy NORRIS-THERMADOR Corporation, Los Angeles, California.

FREE TECHNICAL BULLETIN MAILED ON REQUEST

Illustrated technical bulletin "Bonderite and Bonderlube As Aids In Cold Forming" contains detailed information. Mailed free on letterhead request.

...pack higher wattage
into less space with

NEW
MINIATURE

OHMITE®
THIN-TYPE

power resistors

ACTUAL SIZE



VITREOUS-ENAMELED COVERING holds winding rigidly in place... protects winding from damage.

UNIFORM WINDING prevents "hot spots" and resultant failures.

STRONG, CERAMIC CORE provides a solid base for winding. Core unaffected by cold, heat, or high humidity.

INTEGRAL MOUNTING BRACKETS distribute heat more evenly throughout resistor and conduct heat away.

The new Ohmite *miniature* thin-type power resistors are now available in three wattage sizes in a wide range of resistance values; two wattage sizes are available from stock; also three wattage sizes available from stock in the standard thin-type resistor... see (*) table below.

Designed especially for use in modern electronic circuitry where space is at a premium, these new miniature units have all the timeproven superiority of standard Ohmite vitreous-enameled resistors. They are only $\frac{1}{8}$ " thick and $\frac{3}{8}$ " wide, and range in length from $\frac{3}{4}$ " to 2".

Because of their compact design, the new Ohmite *miniature* thin-type resistors pack higher wattage into less space. The stacking bracket allows mounting close to the surface and a hollow stud provides for convenient stacking of two or more units. The miniature thin-type rises only $\frac{11}{32}$ " above the mounting surface; stack mounted, four units are less than $\frac{1}{8}$ " in height. Shown in photograph are: 1 Standard Thin-Type Resistors with Unit Brackets; 2 Standard Thin-Type Resistor with Stacking Brackets; 3 Miniature Thin-Type Resistors.

Write on company letterhead for Bulletin 138-B.

MINIATURE THIN-TYPE RESISTORS

Watt Rating

* 10
* 15
* 20

Length of Core

$\frac{3}{4}$ "
1"
2"

Width of Core

$\frac{3}{8}$ "
 $\frac{3}{8}$ "
 $\frac{3}{8}$ "

INTERMEDIATE THIN-TYPE RESISTORS

20
30

1"
1½"

13/16"
13/16"

STANDARD THIN-TYPE RESISTORS

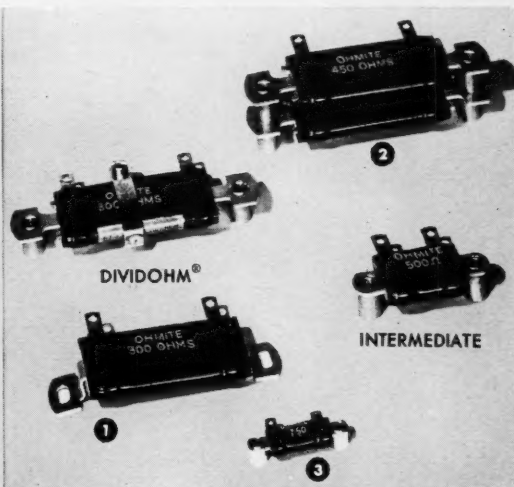
* 30
* 40
* 55
65
75

1¼"
2"
3½"
4¼"
6"

1"
1"
1"
1"
1"

Now available
from stock...

2 miniature sizes:
10 and 20 watts
3 standard sizes:
30, 40, and 55 watts

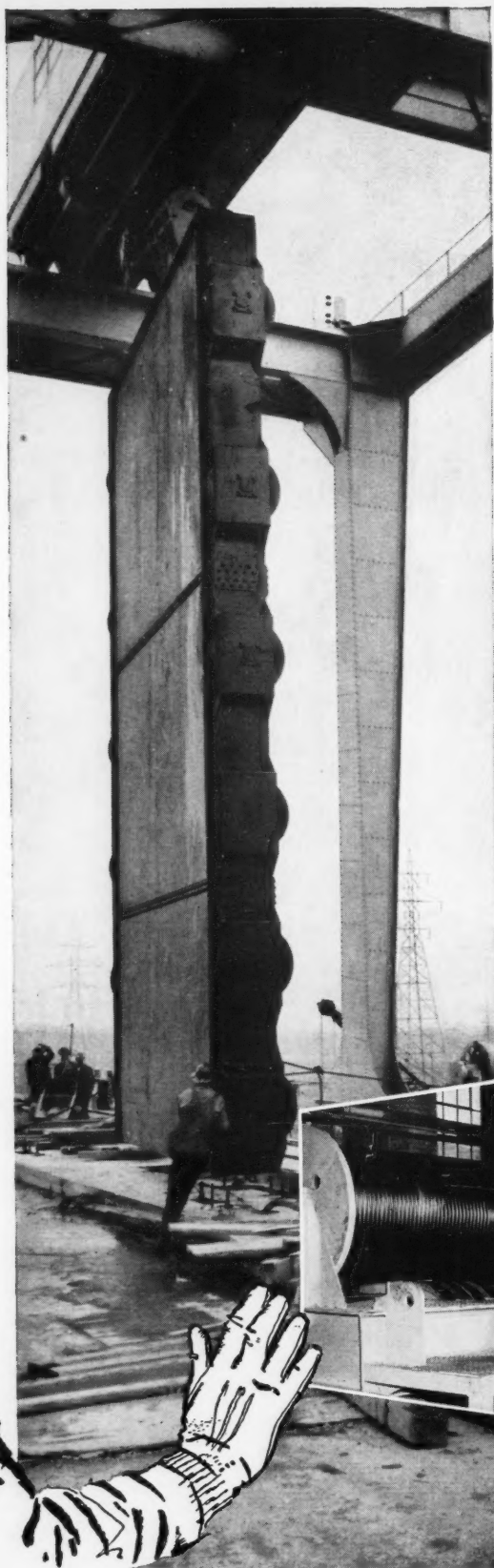


WATTAGE RATINGS ARE BASED ON THE RESISTOR MOUNTED ON A HORIZONTAL STEEL PANEL .040" THICK BY 10" SQUARE. RATINGS SHOULD BE REDUCED APPROXIMATELY 15% FOR NONMETALLIC MOUNTING SURFACE.

BE RIGHT WITH

OHMITE®

RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES • TANTALUM CAPACITORS
OHMITE MANUFACTURING COMPANY • 3688 Howard Street, Skokie, Illinois



Intake Gates

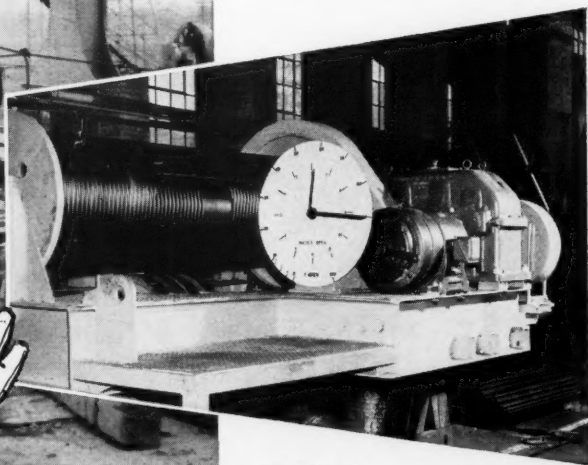
Illustrated is a completely assembled Intake Gate being lowered into position. This is one of twelve built by Canadian Vickers for the Pumped Storage Scheme part of the Sir Adam Beck No. 2 Development of the Hydro Electric Power Commission of Ontario, at Queenstown.

Shop welded in sections and riveted together in the field, these Gates are designed for a clear opening of 16'-8 $\frac{3}{4}$ " wide and 34'-9" high and subjected to a maximum head on the sill of 77'-6".

Canadian Vickers designs and builds all types of Water-Way and Water-Power equipment. If it is Vickers-built . . . it's right.

CANADIAN VICKERS
MONTREAL LIMITED
Toronto MONTREAL Vancouver

A MEMBER OF THE WORLD-WIDE VICKERS GROUP



Shop photo of a Vickers-built Hoist.

HERE IT IS

Cleveland Speed Variator



NOW available in 9 sizes, ranging from one-half to 10 horsepower at 1750 input RPM.

INFINITELY variable, stepless speeds within a 9:1 range (from $\frac{1}{3}$ to 3 times the input speed).

Smooth, instant change of speed by simple manual adjustment or by remote control devices, either manual or power operated.

Operating efficiencies—75% to 90%.

Coaxial input and output shafts, rotating in same direction, either clock-wise or counter clock-wise.

Ample bearing support for both input and output shafts to carry overhung pulleys.

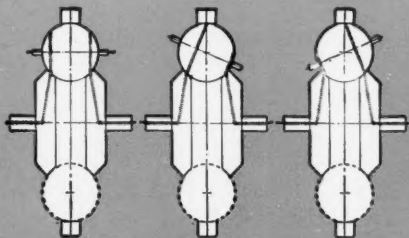
Compact and inherently quiet and smooth running, due to simple construction.

Minimum maintenance and long life, due to absence of belts and other complicated linkage.

Performance proved by prolonged tests in the laboratory and field operation.

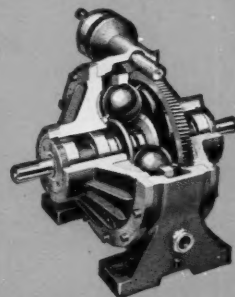
These are the outstanding advantages of the Cleveland Speed Variator. It is now ready for service. Immediately applicable to a wide variety of machines and equipment where a dependable variable speed drive is required. For detailed description and specifications, write for Bulletin K-200.

HOW THE CLEVELAND SPEED VARIATOR WORKS



Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts.

Relative speeds of the shafts are adjusted by changing the positioning of axes on which the balls rotate (see diagrams, left, and cutaway view, right).



Made in U. S. A. by

CLEVELAND WORM & GEAR COMPANY



Sold in Canada by

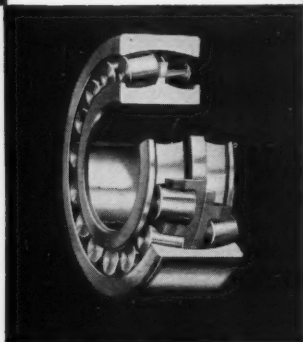
PEACOCK BROTHERS LTD.

P. O. Box 1040, Montreal 3, Que.

Branches in SYDNEY, TORONTO, SUDBURY, WINNIPEG, EDMONTON, CALGARY AND VANCOUVER



The Mountaineer, built by Marion Power Shovel Company, takes a 90-ton bite, piles it 290 feet away to 100 feet high with the help of Torrington Bearings on hoist drum shaft, yoke block, shipper shafts and steering shaft.



World's Mightiest Lift Transmitted Through Torrington Bearings

The Mountaineer, world's largest power shovel, transmits its mighty lifting power — 250 tons — through two Torrington Spherical Roller Bearings on the hoist drum shaft.

Here these bearings operate smoothly at full capacity despite shaft deflections. Four other Spherical Roller Bearings are used in the yoke block to eliminate need for precise alignment of separately bored parts. In all applications, advantages of accurate roller-to-race conformity and positive roller guidance through the integral center flange contribute to long, maintenance-free service life.

To carry thrust of helical gears on shipper shafts and of the steering screw shaft, four Torrington Roller Thrust Bearings are used in each of these assemblies.

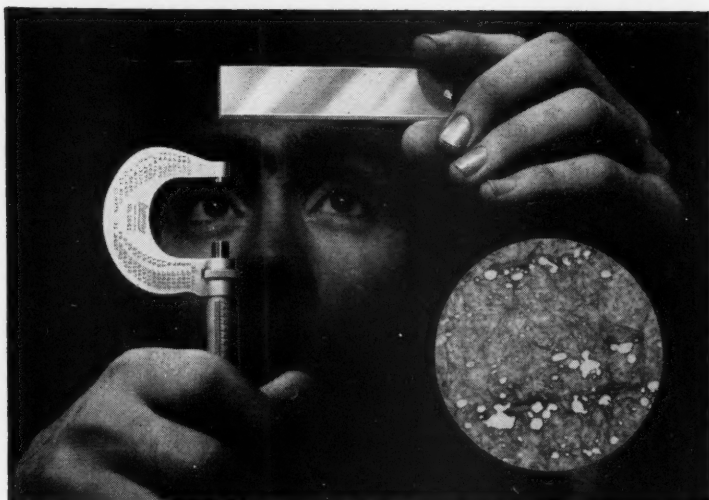
Not only in power shovels, but in all kinds of heavy-duty equipment, Torrington Bearings have proved their efficiency and long service life. The Torrington Company, Limited, 925 Millwood Rd., Toronto 17, Ont.

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

Now—smoother tool finish without grinding



HOW DO YOU BUILD LUBRICATION INTO TOOL STEEL?

The round inset in the above illustration shows a magnified portion of a new Atlas steel with carefully controlled amounts of sulphide particles evenly distributed throughout. Result: built-in lubrication! What's more, most of the properties are virtually unchanged by the addition of sulphur—including impact resistance, forgeability and fatigue life.

TESTS SHOW NEW SIXIX-FM AND FNS-FM, FREE MACHINING STEELS IMPROVE SURFACE FINISH... REDUCE MACHINING TIME

By distributing carefully controlled amounts of sulphide particles evenly throughout these two new steels, we've been able to bring about "built-in lubrication".

The nature and distribution of the sulphide in these two new high alloy steels is *not the same as in free machining low alloy steels*. The type of chip generated by these new steels is not materially different from the unsulphurized stock. In fact the results of impact testing carried out at Atlas have indicated that even impact resistance of the sulphurized and unsulphurized stock is practically identical in most cases.

Technical Data—*Sixix-fm* is a free machining tungsten molybdenum high speed steel of the M-2 type which can be machined to a smooth finish in its annealed condition and so is particularly suited to those tools that are not ground

after heat treatment, such as unground hobs, milling cutters, etc.

FNS-fm is an air hardening, high carbon, high chrome type tool steel possessing a high degree of wear and abrasive resistance. *FNS-fm* is especially suited for tools and dies of intricate design or for those applications where movement in hardening must be kept to a minimum.

New warehouse facilities announced for Hamilton and Montreal

Atlas recently announced plans to complete a new 20,000 sq. ft. warehouse and office building in Montreal this year. And, the 2-year-old Hamilton warehouse will also see a big addition almost doubling its capacity!

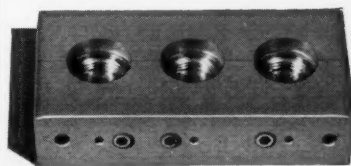
TECHNICAL TIPS from your ATLAS Trouble-Shooter



When to choose oil versus air hardening tool steel

The term "non-deforming" should not be taken too literally, for while these steels are recommended for applications requiring minimum distortion and size change, some movement will occur. The degree of movement is primarily affected by the quenching speed, although the size and shape of the work itself greatly influences the dimensional change that can occur during the hardening of any given grade.

It has been established that where minimum movement in hardening is required, the air hardening steels are the best choice. The oil hardening grades produce slightly greater movement and the water hardening grades cause maximum movement during heat treatment. It therefore follows that the air hardening grades are desirable for dies of very intricate design and the oil hardening grades for dies of intricate design and the water hardening grades for dies of relatively simple design.



Plastic moulding die for battery caps. Good machining characteristics desired. Not necessary to use steel of highest wear resistance since base portion is made as an insert. Recommendation — Oil hardening Keewatin offers good machinability and satisfactory toughness and resistance to abrasion for this job.

ATLAS STEELS LIMITED WELLAND, ONTARIO

WAREHOUSES: MONTREAL, TORONTO,
HAMILTON, WINDSOR, WINNIPEG, VANCOUVER.
REPRESENTATIVES IN LONDON,
ST. CATHARINES AND SUDBURY

MEET Mr. A-C



**CANADIAN
ALLIS-CHALMERS**

LACHINE, QUE. • ST. THOMAS, ONT.



WHO IS HE?

Mr. A-C represents Canadian Allis-Chalmers, and all of Allis-Chalmers. You've seen him in the churches, schools, stores... or met him at civic, social and professional meetings. You've seen him in the shops and offices producing for the betterment of people everywhere, whether in peace or in war.

Just who is Mr. A-C? Because the answer to a question like that is complex, it is easy for people to pick up mistaken impressions.

For the sake of the record, let's take Mr. A-C apart and see who he really is.

WHO IS CAPITAL?

Capital doesn't wear a silk hat at Allis-Chalmers. "Capital" consists of more than 47,000 shareholders. Mr. Capital might be a grocer, a farmer, a widow, a school teacher, or YOU. He might be a company employe in the office or shop or an officer of the company.

This is an example of democratic ownership distinctive in the history of large corporations.

WHO IS MANAGEMENT?

Management is the guiding hand (or head) hired by the owners to make an organization tick—and click! Management coordinates the efforts of individuals and sets the direction the company travels.

Who is Mr. Management at Allis-Chalmers? Not just the officers and division heads of the company. Management is the salesman in the field, the foreman in the shop.

Management is every employe from errand boy to president who contributes by word and deed to the progress of the company.

Speaking of errand boys, one of the top officers of Allis-Chalmers started with that job. Three others started as student engineers. Five began in the sales organization, while another officer started as a machinist in the Allis-Chalmers shops. All Allis-Chalmers officers know the business from the ground up—through experience with the company.

Mr. Management doesn't wear a high wing collar at Allis-Chalmers. Neither does he have any monopoly on his job.

WHO IS LABOR?

The man who works in the shop is spoken of in the newspaper as "labor". Actually, he may be a skilled craftsman, as much as master of his trade as a dentist or a surgeon.

Actually he may be part of *Capital* through ownership of company stock.

The fact that he works with his hands makes him no less a part of Allis-Chalmers than the man or woman who works at a desk. The terms "Capital", "Management", and "Labor" are indefinite and overlapping. Many a man who works in the shop is actually a part of all three groups.

INTRODUCING MR. A-C

Who then is Mr. A-C? He is a combination of 47,000 shareholders, 40,000 employes, more than 5,000 dealers and their employes, more than 10,000 suppliers who furnish in excess of 100,000 separate items for manufacture.

His is a company which contributes something to better living in nearly every home in Canada and the United States—in supplying machines to grow and process food, generate electricity, pump water, build roads, produce building materials.

Mr. A-C is a potent contributor to the welfare and livelihood of millions of people. It takes the right hand, left hand, head, heart and pocketbook to achieve such results. No one part of him can do the job alone.

★ CHOICE OF BUILT-IN
VALVES GIVES
CONTROL FLEXIBILITY

★ SINGLE AIR
CONNECTION
SIMPLIFIES INSTALLATION



★ RUGGED CONSTRUCTION
ASSURES LONG LIFE

★ 125 BELLOWS
SALES AND SERVICE
FIELD ENGINEERS

■ There are one or more Bellows Field Engineers in every industrial area of the United States and Canada. They will be happy to work with you in applying "Controlled-Air-Power" to your machine designs. They are listed in their local phone directories under "The Bellows Co."

758-B

Four reasons why **THE BELLOWS AIR MOTOR** stands first with design engineers

In designing for air cylinder operation the engineer wants first of all sure, positive control, easily interlocked to related machine movements. He has it in The Bellows Air Motor.

He wants simple installation, uncomplicated by cumbersome piping. He has it in The Bellows Air Motor.

He wants rugged construction — an air cylinder that will stand up day in and day out with minimum requirements for service and repairs. He has it in The Bellows Air Motor.

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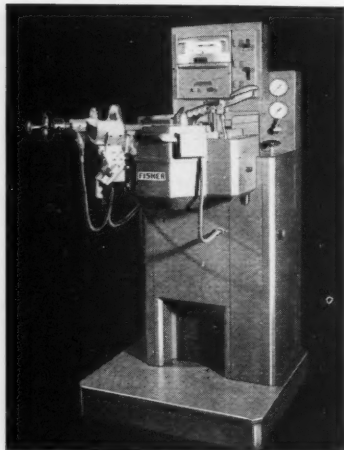


This free booklet offers interesting data for the design engineer. Write for it today. Address Dept. DE-557. Ask for Bulletin BM-25. The Bellows Co., Akron 9, Ohio. In Canada: Bellows Pneumatic Devices of Canada, Ltd.

Welded Design

**ADDS TO APPEARANCE AND STRENGTH
... CUTS COST**

(Below) Original die casting machine made by Fisher Gauge Works, Peterborough, Ont.



NEW

NEW

NEW



New welded design (right) eliminates bar framework—reduces number of component parts by 50%.

Above are the "before and after" pictures of this compact die casting machine—see how redesign in welded plate has smoothed off surfaces, added rigidity and strength.

Sturdiness was a must — to provide greater protection for delicate instruments and to dispense with the need for bolting the machine to the operating floor.

Today, designers are alive to the advantages of welded steel construction over other methods — including casting. It saves time and materials . . . makes stronger, longer - lasting products . . . and provides many production short-cuts.

LINCOLN can help you with welded design

The new 11th edition Welding Procedure Handbook, available from Lincoln at cost will be a valuable addition to your technical library.

Ask for particulars of Lincoln's Weldesign Course arranged especially for Designers.

Write for your free copy of "Elements of WELDesign" — a guide to better products at lower cost. Issued quarterly.

Ask for a Lincoln representative to assist in conversion to welded design.

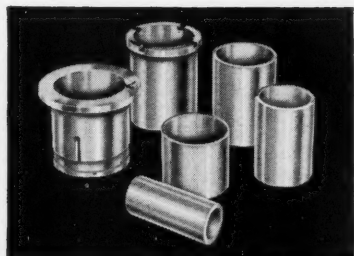


LINCOLN ELECTRIC CO. OF CANADA LTD., 179 WICKSTEED AVENUE, LEASIDE (TORONTO 17), ONT.

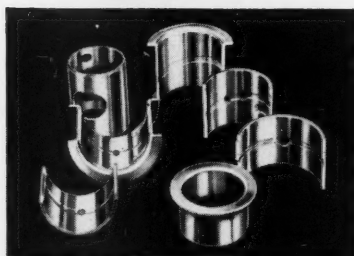


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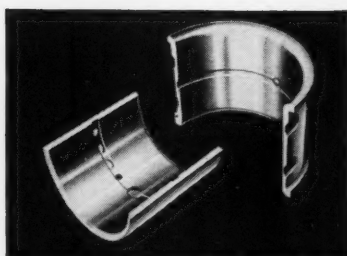
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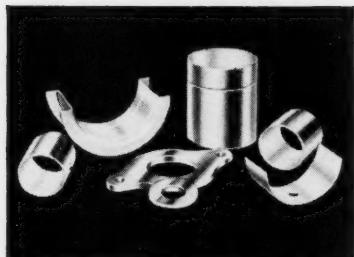
CAST BRONZE



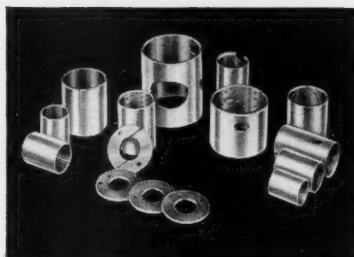
BABBITT AND STEEL



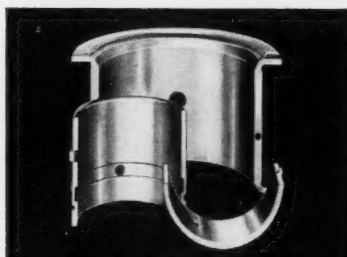
BABBITT AND BRONZE



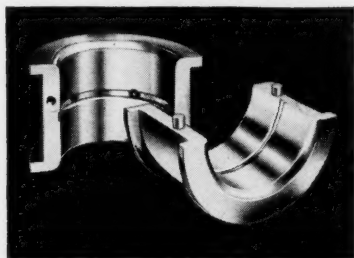
BRONZE OR COPPER-LEAD ON STEEL



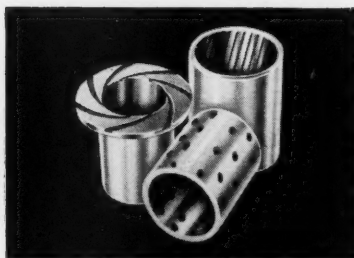
ROLLED BRONZE



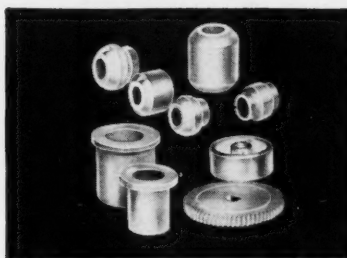
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With measurement an increasingly important function in industry — and Simpson instruments a major factor in the instrumentation field — then Canadian industry and Canadian made Simpson instruments have much in common.

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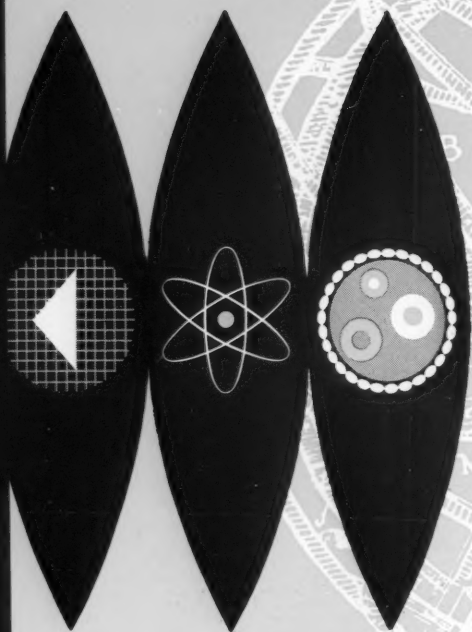
The colorful face of a juke box, the smart new cabinets of radio and television sets are molded of Lustrex, Monsanto's polystyrene plastic. The cables that carry broadcasts over distant networks are reinforced and protected by Ultron, Monsanto's vinyl plastic, which also forms the discs for new Hi-Fi recordings. Component parts in giant telecommunication systems, too, are intricately molded plastics.

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—molded and laminated components for electronics equipment.

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Monsanto technical service bulletins, containing detailed information on chemicals and plastics suited to your needs, are available free on request.

FOR THE

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Throughout the industry Monsanto chemicals and plastics are playing a vital part, easing production problems and improving product efficiency. Some of the principal applications are listed on the left.

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They designed and produced this lot to our
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Manufacturers of all types of products which incorporate castings are discovering new production economies when they specify castings from C.S.I. And the reason is simple—the exclusive method of "clean casting" developed by Canadian Steel Improvement Limited means reduced finishing time. And, since the cost of C.S.I. castings is competitive, savings are made right down the assembly line, resulting in better products at lower cost.

Canadian Steel Improvement Limited cast aluminum and magnesium in sand, permanent mould, and pressure die. Call C.S.I. today on any casting problem. Get superior "clean casting" quality at highly competitive prices.



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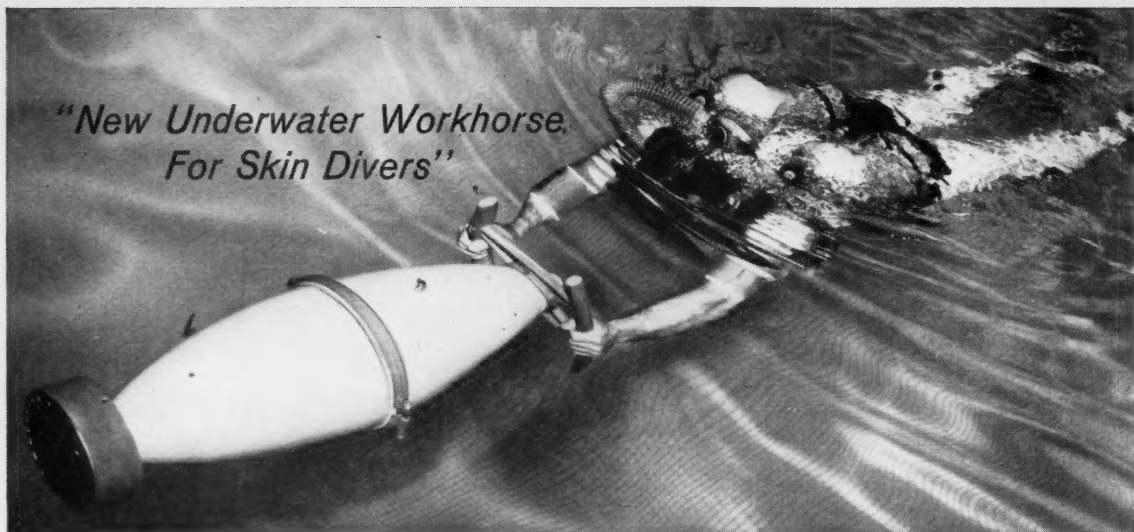
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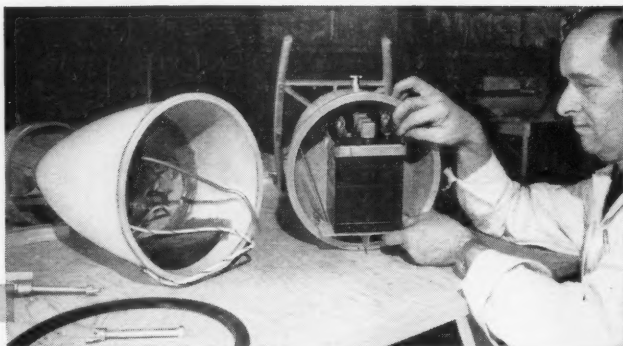
5516

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*"New Underwater Workhorse.
For Skin Divers"*



Constructed With Sturdy, Dependable **POLYLITE** Resin



● Top performance under tough conditions . . . that's what's required of these one man underwater propulsion units made by the Link Aeronautical Corporation of Endicott, New York.

The basic shell material for this "Power Diver" must be able to withstand the pressures of 100-foot dives . . . must be able to resist the corrosive effect of the sea . . . and must still be light enough for a man to carry the unit out of the water. These are just some of the physical requirements that must be met for such a product as this . . . and met at a price that doesn't take the product out of the sportsman's reach!

"That's why we chose a combination of RCI POLYLITE and fibrous glass," states Felix Aimonetti, vice president and general manager of Link. "From the standpoint of design, engineering and cost, reinforced POLYLITE was

the perfect solution for our shell material.

"Besides all this, the capital outlay we needed for this type of construction was relatively low, and we found that even without the benefit of prior manufacturing know-how during the first weeks of production, we were able to turn out a consistently uniform product. All things considered, the use of RCI POLYLITE reinforced with fibrous glass has cut our production costs at least 75%."

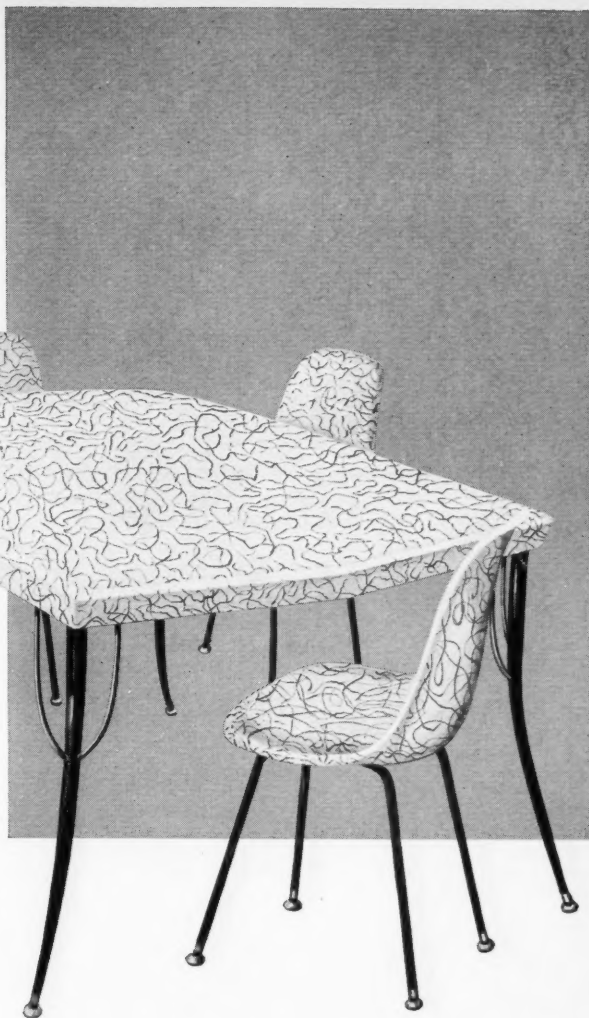
Products possessing the unique advantages of RCI POLYLITE — lightweight strength, durability, and easy maintenance — are becoming increasingly popular and profitable in today's market. Perhaps POLYLITE polyester resin can be incorporated into one of your products. For additional information about what you can do with RCI POLYLITE in laminating, molding or other plastics applications, write for free *Booklet A*.

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Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol
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REICHHOLD CHEMICALS (CANADA), LTD. • 1919 Wilson Ave., (Weston), Toronto 15, Ontario



Vibrin* joins the family circle

Decorator elegance, graceful lines, a virtually mar-proof finish, and complete matching of table and chairs—all these advantages are combined in this new dinette set by Milsam Corporation of Montreal.

Like so many new products, the Milsam dinette set is the result of creative imagination and a versatile material. The material is Vibrin, a polyester resin made in Canada by Naugatuck Chemicals, combined with fibrous glass.

Reinforced Vibrin has many desirable properties—light weight, strength greater than steel for its weight, imperviousness to rot or rust, and complete resistance

to denting. Most important to manufacturers, molds and tools need not be expensive as reinforced Vibrin can easily be formed with low pressure and heat.

The Milsam dinette set is only one of the many uses for reinforced Vibrin. Others include boat hulls, car and truck bodies, aircraft parts, translucent sheeting, machine housings, and chemical piping, to mention but a few.

If you are concerned with improving present products, or giving reality to new ideas, Vibrin may be the material you need. A call to Naugatuck Chemicals at Elmira, Ontario, or branches in Montreal, Toronto and Winnipeg will bring you complete information and expert technical assistance.



OTHER NAUGATUCK PLASTICS:

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Vinyl resins offering good physicals, easy processing, low temperature flexibility, and resistance to oils, acids and wear.

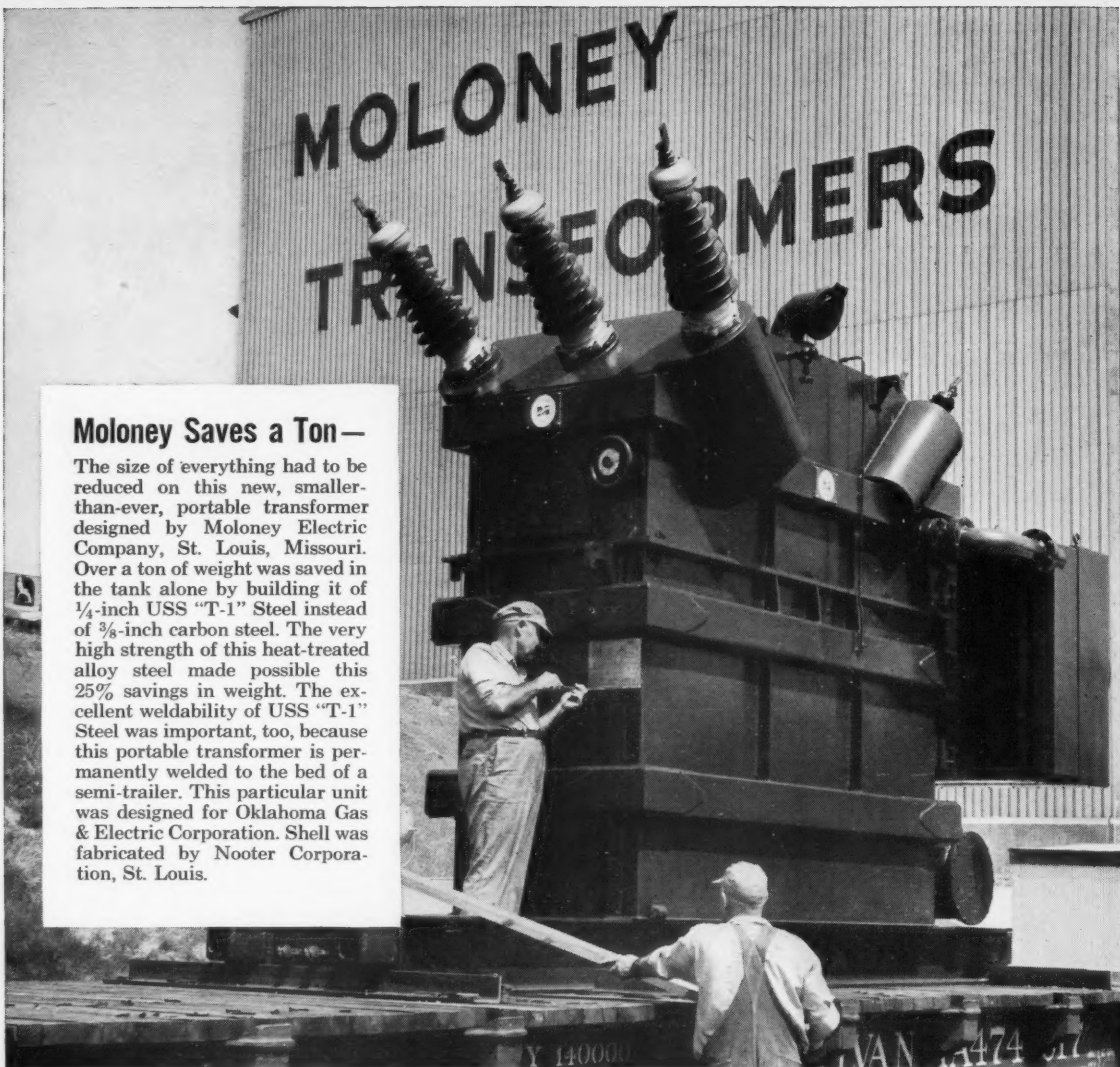
KRALASTICS

Molding and extrusion compounds combining rigidity with exceptional toughness.

MOLONEY TRANSFORMERS

Moloney Saves a Ton—

The size of everything had to be reduced on this new, smaller-than-ever, portable transformer designed by Moloney Electric Company, St. Louis, Missouri. Over a ton of weight was saved in the tank alone by building it of 1/4-inch USS "T-1" Steel instead of 3/8-inch carbon steel. The very high strength of this heat-treated alloy steel made possible this 25% savings in weight. The excellent weldability of USS "T-1" Steel was important, too, because this portable transformer is permanently welded to the bed of a semi-trailer. This particular unit was designed for Oklahoma Gas & Electric Corporation. Shell was fabricated by Nooter Corporation, St. Louis.



HOW IT CAN HELP YOU

USS "T-1" Steel, with its high minimum yield strength of 90,000 psi and its minimum tensile strength of 105,000 psi, can help you design and build lighter-weight equipment that will last longer. Its unusual toughness can help you design or build equipment capable of taking severe impact and abuse at sub-zero temperatures. Its weldability can help you cut the cost of fabricating high-strength parts, and reduce repair and maintenance expenses. Its good creep rupture strength can help you put more durability in equipment that operates at tempera-

tures as high as 900 degrees F.

Somewhere in your operation, versatile USS "T-1" Steel can help you. It is furnished to the published properties. Where applications require maximum resistance to impact abrasion only, USS "T-1" can be furnished to a Brinell 321 minimum hardness. In this condition all other mechanical properties are waived. For further detailed information, write for our new booklet USS—"T-1" Steel . . . United States Steel Export Company, Royal Bank Building, Toronto 1, Ontario.



USS ^{"T-1"} **CONSTRUCTIONAL ALLOY STEEL**
TRADEMARK

UNITED STATES STEEL EXPORT COMPANY

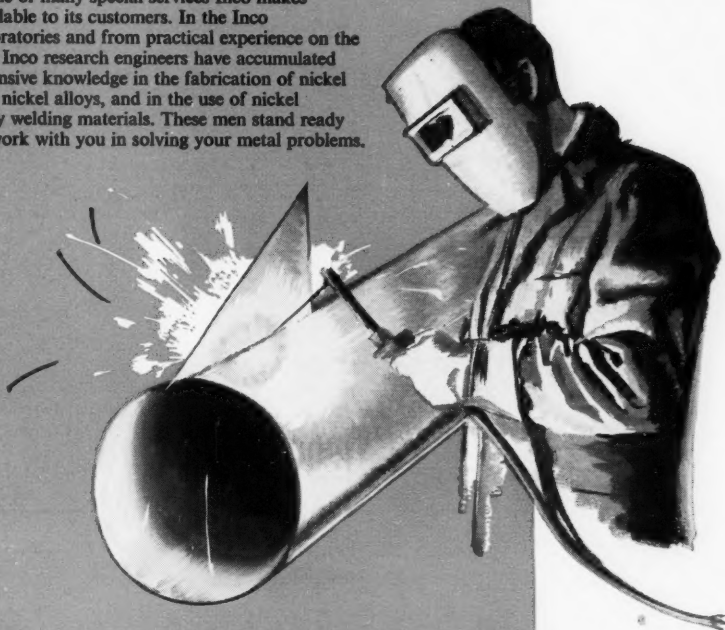
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is one of many special services Inco makes available to its customers. In the Inco laboratories and from practical experience on the job, Inco research engineers have accumulated extensive knowledge in the fabrication of nickel and nickel alloys, and in the use of nickel alloy welding materials. These men stand ready to work with you in solving your metal problems.



**ANOTHER EXAMPLE
OF THE WAY**

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HELPS SOLVE YOUR METAL PROBLEMS

Welding and fabrication is only one phase of Inco Customer Service at work. For almost 35 years, Inco's Development and Research Division has made a comprehensive study of metal problems. Through Inco Customer Service, their research findings are available to you.

If you have metal problems involving welding and fabrication, corrosion, foundry practice, high and low temperature service, mechanical and physical properties, performance characteristics or metals selection, call on us. Your problem may already be treated in some of the literature of the Division. If not, our research engineers are available for consultation and on-the-job assistance. They will give your problem careful consideration and make every effort to come up with the solution. That's why we say:

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Inco Customer Service is as near as your telephone

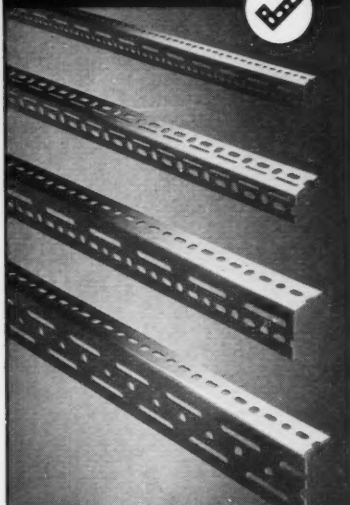


THE INTERNATIONAL NICKEL COMPANY OF CANADA, LIMITED

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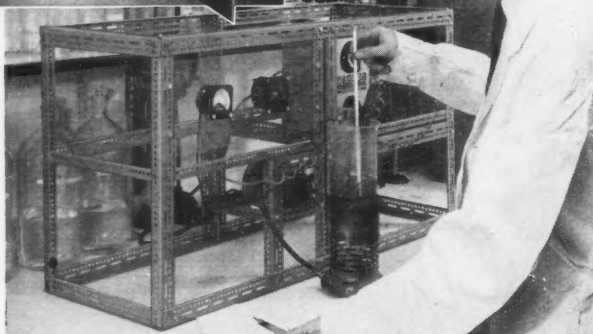
DEXION

announces 2 new angles to round out the world's finest SLOTTED ANGLE CONSTRUCTION SYSTEM



An instant success upon its introduction in Canada, world-famous Dexion 225 was soon followed by Dexion 300 in response to demand for a heavier section angle. And now, another new chapter in the Dexion success story unfolds with the introduction of two *lighter duty* angles — 112 and 140. With this family of four angles (all designed to be used together) industry now has a range never before offered. Here is the ideal system for solving countless storage and equipment problems — quickly, easily, inexpensively.

DEXION 112



TYPICAL USE OF DEXION 112. This laboratory set-up is a good example of how half-size 112 fills the bill to perfection for an application where 225 would be needlessly strong and heavy.

Midget DEXION 112

A half-size version of famous 225, Dexion 112 is the smallest angle in the Dexion system. 112 is ideal for models, display stands and frames, small laboratory and workshop frame-works, etc., and for an even wider range of jobs when used with 140.

112 STEEL and 112 ALUMINUM ALLOY
1 1/4" x 3/4" x .048"
Both in packages of 100 feet (20 x 5')
with 200 nuts and bolts.

Light Duty DEXION 140

This new angle, smaller than famous Dexion 225, has equal flanges and is designed to bolt together with all the other Dexion angles. It is ideal for many jobs in factory, store, and office where the strength of 225 is not needed, or for lightly stressed members in bigger structures.

140 STEEL 1 3/8" x 1 3/8" x .070"
140 ALUMINUM ALLOY—1 3/8" x 1 3/8" x .080"
Both in packages of 100 feet (10 x 10')
with 75 nuts and bolts.

DEXION 140



TYPICAL USE OF DEXION 140. Light, strong, rigid and neat looking, this table and the shelves in the background will suggest endless other uses for light duty 140 angle.

Full details, prices & samples from your DEXION distributor

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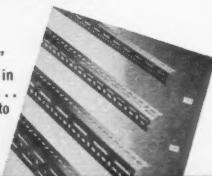
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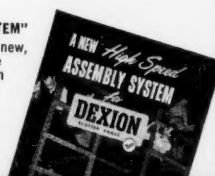
"THE DEXION CONSTRUCTION SYSTEM"
The basic DEXION story in words and photographs... will suggest many ways to save time, money and labour in your plant.



"CANADIAN DEXION NEWS"
A quarterly publication to keep you right up to date with latest developments and uses.



"HIGH SPEED JIG ASSEMBLY SYSTEM"
Describes Dexion's new, simple, inexpensive jig assembly system which doubles and trebles erection speeds, even on jobs using as little as 500 feet.



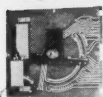
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ELECTRO-SPAN

GIVES YOU THE MOST VERSATILE TANK GAUGING SYSTEM

Programmer



Prints time and date prior to each liquid level gauging.

Calendar/Clock



Automatic digital read-out of minute, hour, day, month and year.

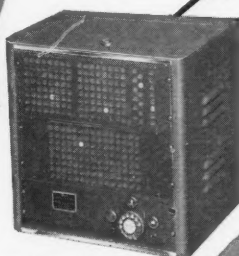
Card Punch



Permanent record of selected gauging for automatic data processing equipment.

Remote Tank Selector

Single Wire Pair



Indicating Receiver/Control

Auto Sequential Scanner



All or selected tanks are read in sequence automatically.

Cycle Timer



Orders the read-out of tanks at pre-set time or time intervals.

Electric Typewriter



Provides easily read, permanent log of all (or selected) gaugings.

With Electro-Span Gauging Systems you can secure *any* arrangement of a basic system — together with a unique selection of input and readout equipment — to meet virtually every requirement.

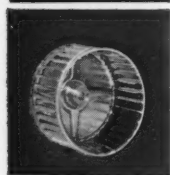
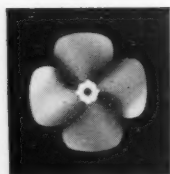
The Electro-Span System is an inexpensive digital pulse-code system for the measurement and control of any number of tanks.

Tank levels to $\frac{1}{8}$ ", and averaging temperatures if desired, are displayed on lamp registers.

In addition, all of the important accessories shown above can be provided to give you the most complete tank gauging system available today.



COMPUTING DEVICES OF CANADA LIMITED
P.O. BOX 508 • OTTAWA • CANADA



SOLUTIONS UNLIMITED

Torrington is the one place where engineers work *only* on air moving problems in the development of air impellers supplying the full range of industrial requirements.

As a result, more air moving problems are being studied today in Torrington's Research and Development Laboratory than anywhere else in the world.

If you have product problems relating to the design, application and performance of air impellers, *talk to Torrington.*

THE TORRINGTON MANUFACTURING COMPANY

OF CANADA LIMITED

OAKVILLE, ONTARIO • TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA

People

Important people who are in the news

Diesel power

The Canadian Car & Foundry Co. has recently announced the creation of a diesel and engineering division for the development of the use of diesel power in a wide range of transport and industrial applications.

At the same time, the appointment of **A. J. Charnock** to the position of vice-president of the newly formed division. Mr. Charnock was formerly general manager of the company's plant at Longueuil, Que.

Charnock was director and general manager of Leyland Motors (Canada) before Can-Car took over the operations of the plant in 1956. In 1953 he came to Canada from England where he had been associated with Leyland Motors Ltd., in Lancashire for 26 years.

In his earlier years he was a staff lecturer in the engineering department of the Blackburn Technical College. He was awarded the O.B.E., Civil Division, in 1951.

Winners announced

The winners of ten international education awards for 1957-58 in the \$7,000 scholarship contest sponsored annually by the American Society of Tool Engineers have been announced.

Among the winners is **Richard W. Warkentin** of Owen Sound, Ont., who is attending Queen's University in Kingston.

A Canadian honorary member

Dr. Edward Warner, president of the Council of the International Civil Aviation Organization in Montreal, becomes the first honorary member of the International Society of Aviation Writers at ISAW's first general meeting in Washington, D.C., April 2-6.

This honor is given to Dr. Warner "in recognition of a lifetime of inspiring leadership and devoted effort in the cause of internationalism, civil aviation, aeronautical education and professional aviation writing." ISAW, which was formed last June at San Francisco, birthplace of the United Nations, now numbers a rapidly growing membership of over 400 leading aviation writers from 35 different countries.

Walker joins Hunting

R. L. Walker, B.A.Sc., P.Eng., has joined Hunting Technical & Exploration Services Ltd. His first assignment with the Toronto firm will be in Ceylon where he will act in a liaison and co-ordinating

capacity in connection with studies of the island's water resources under the present Canadian Colombo Plan integrated survey.

Cunningham is manager

William Cunningham has been appointed manager of the B. F. Sturtevant Co., of Canada Ltd., a Canadian Westinghouse subsidiary at Galt, Ont. The firm was previously headed by K. W. Fraser who was recently appointed Pacific District Manager for Westinghouse.

Formerly defense contracts co-ordinator for Westinghouse, Mr. Cunningham joined the company in 1954 after serving for three years as deputy director of the Dept. of Defence Productions Shipbuilding Dept., Ottawa. He was assistant director general, naval armament and equipment, Dept. of Munitions and Supply, during wartime years and received the M.B.E., for services with that department.

He will be responsible for all engineering, manufacturing and sales activities at the B. F. Sturtevant Co.

Director elected

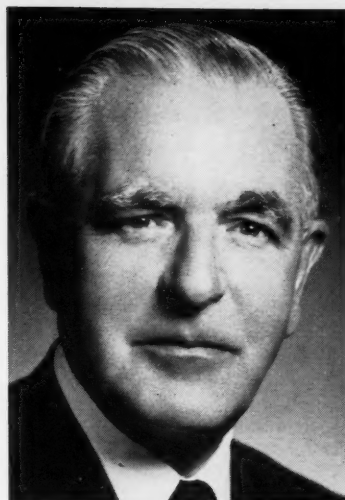
A recent release coming to our desk told us of the election of new officers and directors by the National Association of Corrosion Engineers, which has its offices in Houston, Texas. It was interesting to note that among the five directors appointed, one of them was **R. E. Kuster** of the Union Gas Co., of Canada in Chatham, Ont.

Two at UCC

News of two appointments within their organization comes from Union Carbide Canada Ltd. They are **J. Stuart Johnston, P.Eng.**, as sales manager, industrial gas products of Linde Air Products Co., and **Douglas G. Gallop** as technical representative, Bakelite Co. Both these companies are divisions of UCC.

A graduate in mechanical engineering from McGill University, Mr. Johnston joined Linde in 1939. In the intervening years he has held positions in Montreal, Toronto, Winnipeg and Vancouver. He is a member of the Canadian Welding Society, the Engineering Institute of Canada, and the Association of Professional Engineers of the Province of B.C.

Mr. Gallop was graduated in mechanical engineering from the University of Toronto in 1956 with the degree of B.A.Sc. During vacations he was engaged as project engineer in three different industries.



Charnock



Johnston



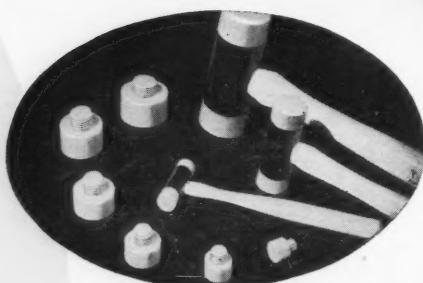
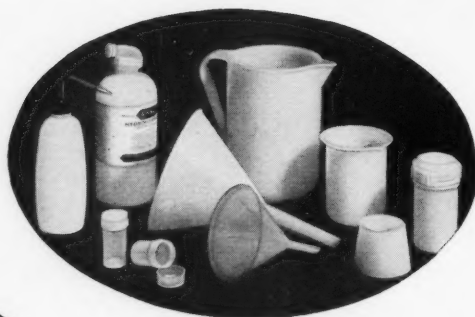
Gallop

Today's needs and
tomorrow's projects call for

POLYTHENE

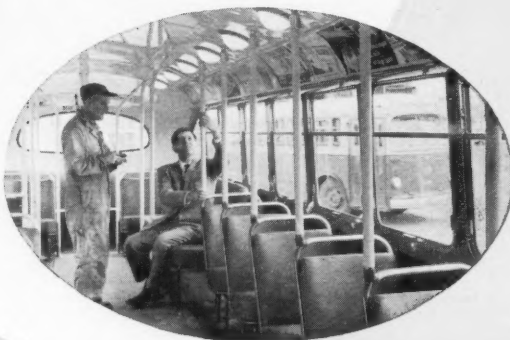
in laboratory

work, equipment and utensils of sturdy polythene will not chip, crack or break and can safely contain almost all corrosive chemicals.



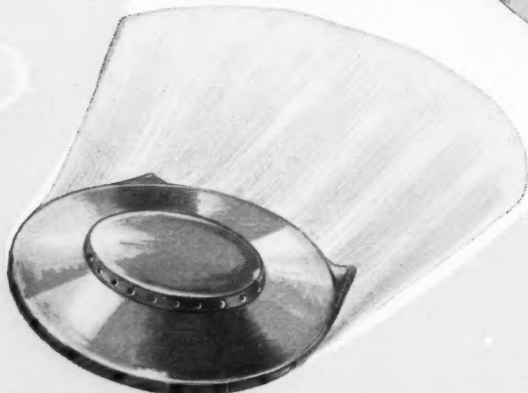
workshop

practice these days calls for replaceable hammer heads such as those of polythene; tough enough to drive close tolerance parts, yet resilient enough not to mark or distort them.



and everyday life

polythene covering the hand rails in this bus provides a better grip, protects the rail from saline corrosion, cleans easily, is pleasant to the touch.



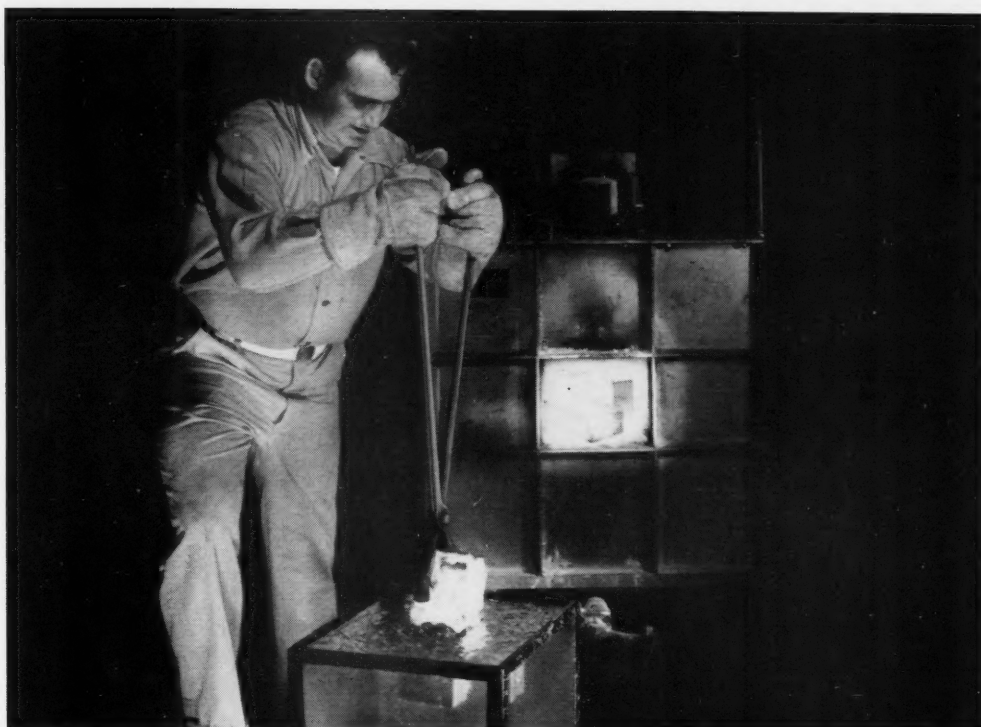
designers!

USE POLYTHENE'S SPECIAL PROPERTIES! it's light, tough, non-toxic, chemically inert; has exceptional dielectric characteristics, remains flexible and strong even at sub-zero temperatures.

C-I-L Plastics Division, P.O. Box 10,
Montreal, supplies polythene
resin to convertors.



POLYTHENE



Ceramic-bonded silicon carbide brick at 2462 deg. F. was plunged into cold water. Brick did not crack.

No metal resists such wear and heat

To most design engineers, refractories as a class have held little interest, for they didn't lend themselves to being formed into the relatively thin-section, intricate shapes that can be held to close dimensional tolerances. In addition, their favorable characteristics were usually offset by others that were undesirable in equipment parts, so that tradition (and experience) relegated them to the category of heat-containing materials of construction.

In recent years, however, a group of silicon carbide refractories have emerged that merit careful attention by those engaged in design work. Uncommon properties (and a broad range of shape formability) narrow the gap between refractories and metals. Significantly, initial costs are lower than for heat-resistant alloys, which they often outlast.

**Recent developments
in refractory materials have given
design engineers good
cause to sit up and take notice of
their good properties ▶**

By R. W. Brown

THE CARBORUNDUM CO.

The cost of refractory materials is less than heat-resistant alloys

Most silicon carbide refractories employ ceramic or siliceous bonds that fuse on firing.

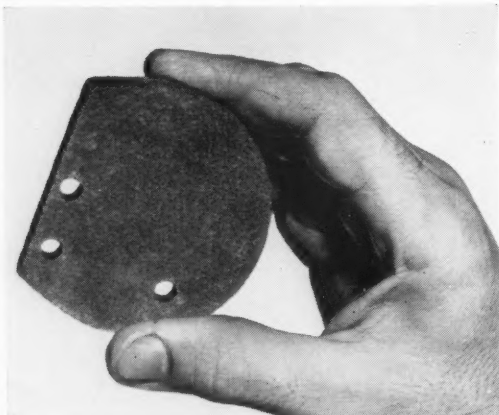
Silicon carbide is produced in electric furnaces at 4,000 F from a mixture of sand and coke. The black, hexagonal crystal that forms is extremely hard and does not soften, melt or dissociate below its temperature of formation. It is also strong, has high heat conductivity, resists abrasion and corrosion and withstands thermal shock. The degree to which these prop-

erties are retained in finished refractory pieces depends to a large extent on the type of bond holding the crystals together.

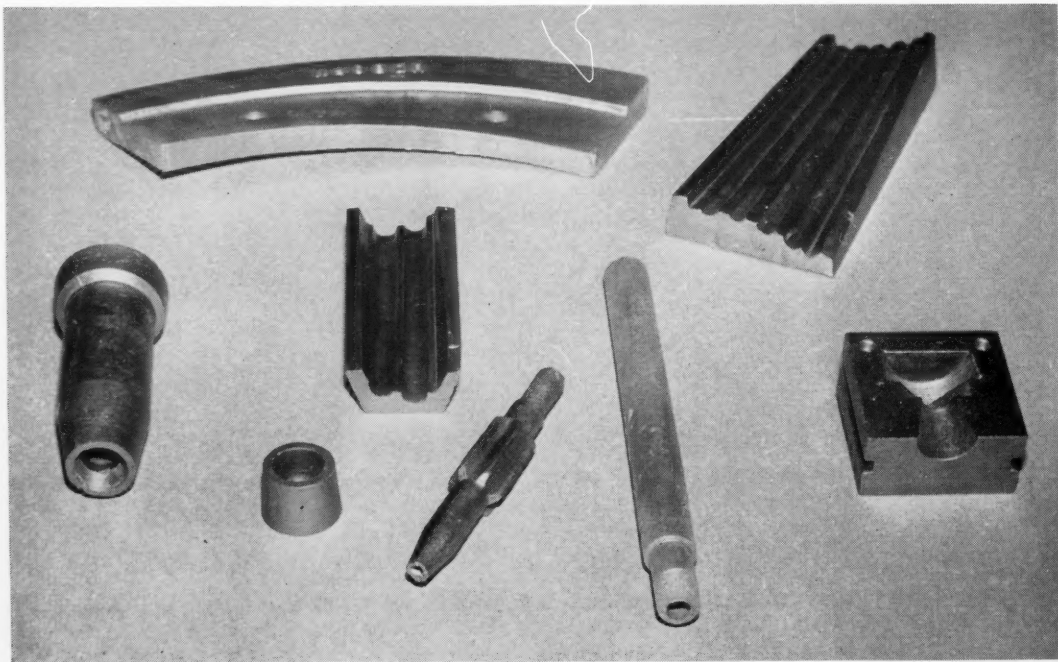
A newer class of products uses a chemical bond that develops in situ by nitriding silicon metal. In contrast, the latter produces a stronger bond that increases refractory strength, provides greater resistance to corrosion and heat shock and permits closer dimensional tolerances ($\pm .003$ to $\pm .005$ in. of dimension) since it undergoes no volume change during firing. It is neither wet nor attacked by molten aluminum, a melt which is notoriously corrosive toward all metals.

Ceramic-bonded, silicon carbide refractories are manufactured by compacting and pressing. The same methods (plus casting) are used for the chemical-bonded products. Cast shapes have a surface finish of about 250 micro-in., as compared with over 500 micro-in. for compacted and pressed parts. While shape surfaces can be machined, it is a difficult operation and one which does not give the finish obtained with metal. Shape, quantity, application and surface finish determine the method of manufacture.

Like other non-metals, silicon carbide refractories are stronger in compression than in tension. The chemical-bonded material, for example, at 68 F has a compressive strength of 20,000 psi and a tensile of 3,500 psi. Comparable figures for ceramic-bonded products are 15,000 psi (compression) and 2,300 psi (tensile). Frequently, advantage can be taken of this compressive strength by the redesign of auxiliary equipment



Shield quenches the arc in circuit-breaker equipment.



An extremely wide range of shapes can be produced from chemical-bonded silicon carbide. Among those shown here are a thermocouple protection tube, mould for cutting brass parts and a burner part for ceramic kilns.

	Heat resisting steels			Silicon carbide refractories	
	304	310	446	Ceramic Bonded	Chemical Bonded
Melting range (F)	2550-2590	2550-2650	2550-2750		
Density (lb/cu in.)	0.29	0.29	0.27	0.092	0.101
Thermal conductivity at temp. indicated (Btu/hr/ sq ft/deg F/ft of thickness)	9.4(212F) 12.4(932F)	8.0(212F) 10.8(932F)	12.1(212F) 14.1(932F)	8.7(1000F) 9.4(2900F)	9.9(1000F) 9.6(2900F)
Coefficient of expansion $\times 10^6$ per deg F. From 68F to temp. indicated	10.6(1700F)	10.9(2100F)	—	2.6(2500F)	2.6(2500F)
Specific heat (Btu/lb/deg F)	0.12	0.12	0.12	0.28	0.29
Maximum service temperature in air (deg F)					
Continuous service	1600	1900	2000	2800	2950
Intermittent service	1700	2100	2150	3100	3200
Modulus of Rupture (psi at 2400 F)	—	—	—	2000	5600
Refractoriness, pyrometric cone equivalent	—	—	—	38	—

to lower tensile stresses. Threaded connections between refractory and metal parts, for instance, can be handled by making the refractory with external threads, thereby avoiding the tension that would otherwise result from differential expansion during heating and cooling.

Good shape design is important, for while many configurations can be produced, all are not practical, either from a manufacturing or a service standpoint. In general, heavy central bodies incorporating thin-section appendages (and shapes with abrupt changes of direction and section) are undesirable.

Large shapes should be sectionalized when severe thermal gradients are anticipated, since smaller segments are less apt to crack from heat shock. Thin sections and knife edges have low strength and are fragile.

Even with these silicon carbide refractories, it is impossible to establish precise limitations, as can be done with metals. Tubes receive different consideration than tile; shapes are viewed from still other angles. Parts approximately 50 in. long in one direction can be made of ceramic-bonded silicon carbide whereas in chemical-bonded material this dimension is about 30 in. Very small pieces (under about $\frac{3}{4}$ in.) are difficult to manufacture; long, narrow shapes tend to warp or twist during the firing operation.

Wall thicknesses less than $\frac{1}{4}$ in. present problems in production and shipment. Sections over 3 in. thick are equally undesirable, because they lower heat shock resistance, mature improperly and increase the mass (and the cost) without a proportionate increase in strength.

Experience shows that close co-operation between



Apex valve orifice for liquid cyclone separator stands up under severe abrasion that would quickly cut metal.



This pump, of chemical-bonded silicon carbide, is used in die-casting aluminum which does not wet refractory.

"They can resist abrasion and corrosion and withstand thermal shock"

After 15 months ceramic-bonded spray nozzle is still in good condition. 8% cast antimony lead lasted only 3.



"Shape, quantity and application determine the method of manufacture"

design engineer (or equipment user) and refractory manufacturer results in a practical shape made of the material best fitted for the service conditions to be encountered. This procedure is further recommended by the fact that both groups of silicon carbide refractory consist of many different varieties, each intended to meet specific needs.

In cost, these materials range from about 25¢ per pound (for simple shapes) to several dollars per pound (for complex parts). As previously indicated, the products offer savings over machined alloy parts.

Application of silicon carbide refractories varies from small parts of equipment (such as electric circuit breakers) to over 20 ft. diameter hearths and arches in ore-roasting furnaces and guided missile components. Temperatures in some instances do not exceed 200 F; in others they exceed 5,000 F.

Perhaps one of the most intriguing uses for the chemical-bonded refractories is the liner and throat of uncooled rocket motors. Fuel burns in the liner and is expelled through the throat. This creates temperatures estimated at 5,500 F, causes severe erosion and intense thermal shock conditions. Nevertheless, these refractory shapes outlast metal many times, because of their ability to dissipate heat rapidly. This performance suggests the material's possibilities as nozzles, combustion chamber liners and exit cones in other designs of rocket motor. Moreover, additional parts of rockets, missiles and jet engine components may lend themselves to manufacture from the product.

Pumps and pump parts (for transferring molten aluminum) as well as valves and fittings (to control its flow) are made from chemical-bonded silicon carbide. Also produced from this material (and used in molten aluminum) are thermocouple tubes, pouring spouts, trough linings, metering devices and floats, as well as linings for induction furnaces.

Resistance of chemical-bonded silicon carbide refractories to this corrosive aluminum melt is exemplified by a life of over 500 hr from thermocouple tubes without any sign of attack. Mechanical failure is the only reason for replacement. Cast iron tubes in the same equipment average 72 hr; they also contaminate the metal to a degree that is unsatisfactory.

Burner tips and nozzles, brazing fixtures, pump housing and abrasive slurries, oil-black furnace parts, mixing venturis, threaded nuts and bolts, tubes, welding fixtures and sinker assemblies are further examples of successful usage. Doubtless others will be developed as engineers become more familiar with the material and its possibilities.

Typical of the accomplishments with ceramic-bonded silicon carbide refractories is their use in vertical retorts, 15 to 30 ft high and of 1 ft by 5 ft cross-section. These retorts are employed for winning metals from ores and for heating carbonaceous material. In the latter (using a reaction temperature of 2,000 F) alloy steel lasted 2 or 3 months. Replacement of the alloy with ceramic-bonded silicon carbide refractories increased the life to 15 or 18 months. Further, operation was safely conducted at higher temperatures and the output quadrupled.

This service illustrates a striking feature of the prod-

uct in process work. As reaction rates increase appreciably with rising temperature, high temperature frequently becomes desirable. While alloys can be used up to about 2,000 F, these refractories will safely take temperatures almost 1,000 F higher. Thus they serve a twofold purpose; they replace the alloy and permit increased rates of output.

Another application where the properties of ceramic-bonded silicon carbide combine to improve an operation is in radiant-heated, roller hearth furnaces. With heating tubes and rolls made of alloy, the maximum temperature is limited to about 1,800 F and life is not overlong. Refractory parts, on the other hand, permit temperatures around 2,500 F, provide a heat conductivity approaching that of metal, possess adequate hot strength and offer greater emissivities and rates of heat absorption. Emissivity compares favorably with that of black bodies, while heat-resisting alloys are only fair in this respect.

Long silicon carbide radiant tubes and rolls are assembled from short sections equipped with special joints. They are held together tightly by end compression which, in some cases, is as much as 1,000 psi at 2,200 F. Several years' service is not unusual.

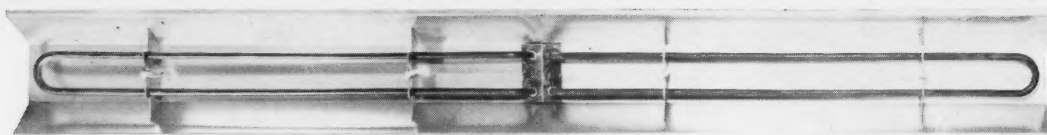
Trying to improve two months' life from acid-proof brick in the cooling chamber used in an SO₂ recovery process, ceramic-bonded silicon carbide refractories were installed in the arch and sidewalls. Gas enters the cooling chamber at 1,700 to 1,800 F. Cooling and preliminary scrubbing is performed by spraying a 15% solution of SO₂ in water (at 150 F) through eight roof nozzles. Despite these corrosive and thermal shock conditions, service life was extended to over two years.

Pyrometer protection tubes and radiation pyrometer blocks made from these ceramic-bonded refractories are used extensively with pyrometric equipment for measuring furnace temperatures. Readings are taken fairly quickly, since the high heat conductivity of the refractory reduces time lag. Most furnace atmospheres do not harm this material and its hot strength prevents slumping, even though thin-section pieces are involved.

Similarly, thin-wall refractory tubes have proved more successful than alloy inside the coil of many induction furnaces for heat treating metal shapes. Not only do they give longer life but, in addition, the first cost is lower than that of alloy, heat flows to the work rapidly and uniformly and the slugs cause little or no wear.

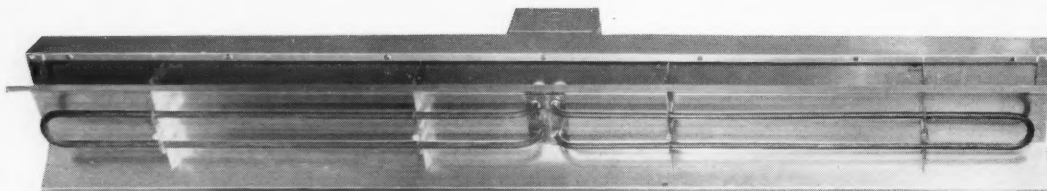
A restaurant-type broiler uses a series of ceramic-bonded silicon carbide tile over gas burners to obtain the radiant surfaces required to broil meats properly. They deliver heat fast and show no deterioration after many months' service.

Both ceramic-bonded and chemical-bonded refractories possess the inherent abrasion resistance of silicon carbide. This has led to a variety of applications, in some of which heat is almost non-existent. Included are slurry-pump parts, ore-washing junction boxes, liquid cyclone separators and spray nozzles. Among the uses for these materials at low or moderate temperatures are cyclone dust collectors, skid rails in sheet, plate, bar and billet heating furnaces, coke chutes, feeder tables, blast furnace downcomers and gas scrubbers. ★



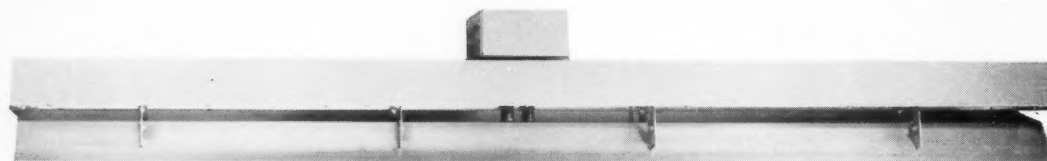
Plug-in elements easily remove for cleaning.

Oven heating with rays we cannot see



Main body of the panel is fibre glass filled.

These ovens combine the advantages of convection and near-infrared



Terminal box is at the back of the panel.

Why far-infrared ovens?

More and more, far-infrared ovens are replacing convection ovens and infrared lamp ovens. This recent trend is for three main reasons:

- (1) Far-infrared heating combines the advantages of convection ovens and near-infrared lamp ovens.
- (2) Maintenance is practically eliminated with tubular radiant heating elements.
- (3) The cost per installed kw is usually lower with far-infrared heating equipment than with other radiation ovens.

Besides being used for the baking and curing of paint or enamel and the drying of wet metal parts, there are a lot of far-infrared applications in industry.

Incoloy-clad radiant Calrod heating elements are successfully being used for drying textiles, paper, coating on mirrors, corundum powder, charcoal briquettes, mining concentrates and clay. They serve to soften plastics and cure foam-plastics and are now being used in the food processing industry for removing the peel from apples and other fruit by means of high intensity radiation. Finally, they lend themselves readily as emergency space-heating units in exposed areas.

G. A. Remiz, P.Eng. CANADIAN GENERAL ELECTRIC

Infrared radiation is emitted by molecular thermal agitation and infrared waves travel with the speed of light. When the waves reach a material that is capable of absorbing infrared radiation, they turn into heat. When, on the other hand they hit a good reflector (such as bright aluminum) the rays bounce back without any noticeable heating effect.

This means that infrared ovens do not require air for their function, as convection ovens do; furthermore, the heat transfer is instantaneous. With convection ovens, air is being used to heat the object and therefore has to be hotter than the object. With infrared ovens, the object is being heated mainly by direct radiation and is much hotter than the surrounding air. This results in reduced heat losses, especially as the reflective walls of infrared ovens do not reach such high temperatures as those of convection ovens.

However, if parts of intricate shape and of various sizes are to be baked, we might find a greater heating uniformity with a convection oven than with an infrared lamp oven.

The above comparison refers to ovens based exclusively on either the radiation or convection principle. In reality, all infrared ovens operate simultaneously on both principles, that is, by direct radiation and by heat transfer by means of heated air. The ratio between

radiation and convection depends on several conditions, such as the temperature of the radiating heat source, the initial temperature of the material to be heated and the thermal absorptivity.

The diagram shows the distribution of various heat sources, related to the spectrum. We see that high temperature heat sources (such as incandescent lamps) have a peak energy close to the "red" limit of the visible spectrum. Their emittance is therefore called **near-infrared** radiation, whereas the rays emitted by lower temperature heaters (such as Calrod units and open wire coils) have a peak energy more remote from the visible section and are called **far-infrared** radiation.

We notice that infrared lamps have the greater part of their energy in the visible section, whereas far-infrared heaters operate either with a very small portion or no energy at all in the visible spectrum.

In almost all industrial applications, both near and far-infrared rays can be used, especially in paint baking and related applications. It is therefore most important to consider all aspects of the application when choosing between the two kinds of heating. In most industrial applications this consideration will lead to the use of far-infrared heaters with a metallic or ceramic surface.

Near-infrared heating (such as is obtained by lamp panels) has certain disadvantages when uniform heating of intricately shaped parts has to be performed, especially when they consist of thin metal sheet (or non-metallic substances) with poor heat conductivity. In this case, overheating may take place on sections facing the lights, whereas parts not "seen" by the rays are still cool.

Far-infrared, using radiant Calrod (or similar heating units) achieves the heating at a lower temperature of the heating source, and therefore comes closer to the performance of convection ovens. The air heated by both the heating elements and the work circulates in the oven, either by natural convection or by fan. This warm air creates a uniformity of temperature that can-

not be obtained when infrared lamp ovens are used.

Furthermore, far-infrared heaters with metallic or ceramic surface are "color blind"; that is, they do not have the undesirable feature of near-infrared equipment of responding differently to various colors. Users of lamp ovens know that white needs a longer baking time than black, due to the different absorptivity of various colors. Because of the longer wave length of far-infrared rays, this effect is much less pronounced and all colors can be baked at about the same time and conveyor speed.

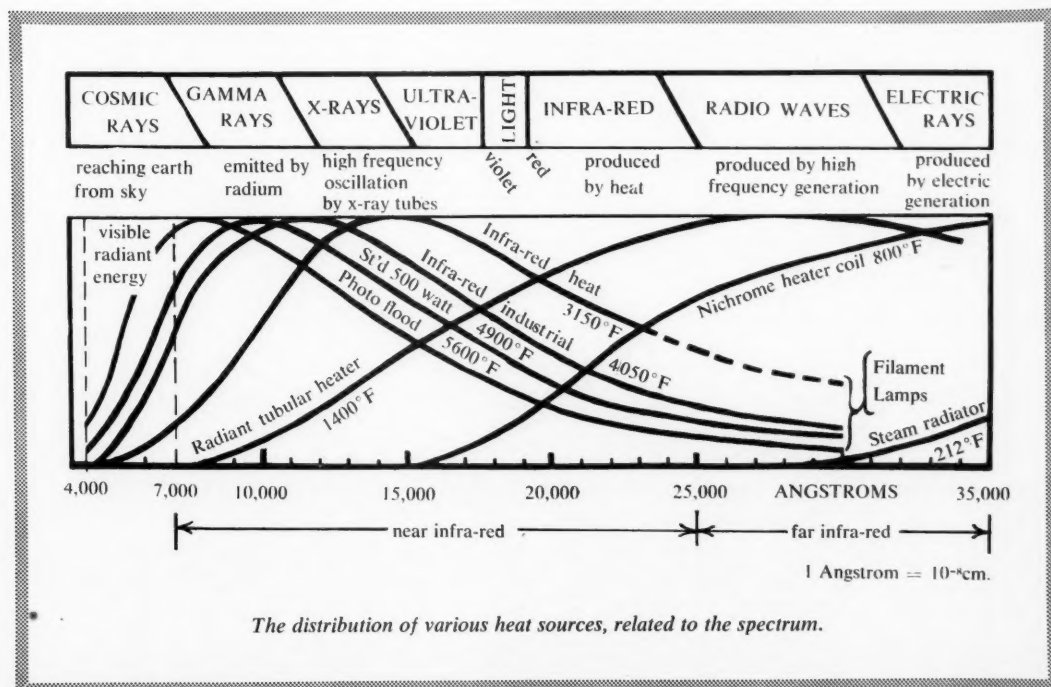
Finally, far-infrared ovens have the advantage of eliminating the insulation of the oven against heat losses, necessary with convection ovens. The highly reflective aluminum sheet re-radiates the infrared rays and enables the oven to be lighter and cheaper than the standard convection oven.

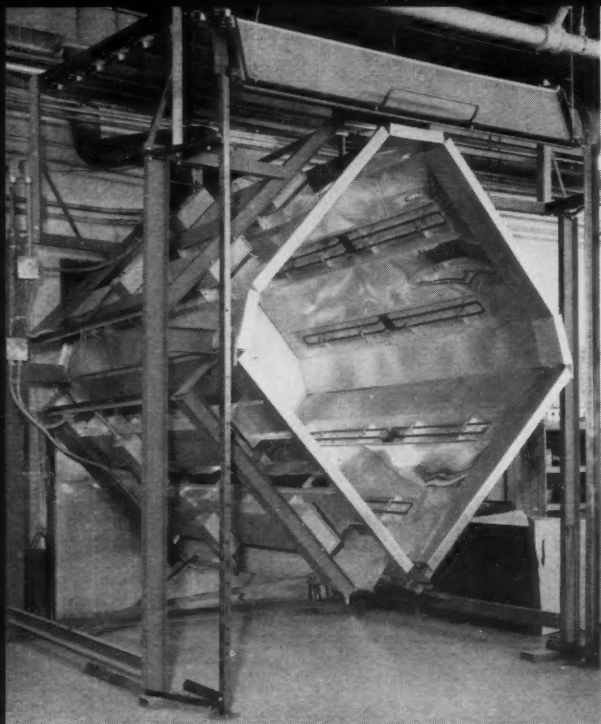
Short life lamp

One of the main disadvantages of infrared lamp installations is the restricted life expectancy of electric lamps. The owner of a large infrared lamp oven faces the necessity of continually replacing burnt-out lamps. One defective lamp usually cuts out four more lamps, since most lamps are built for 115 volts and five lamps are connected in series for the normal line voltage of 575 volts. It is unsatisfactory to have five or ten lamps in one section out of service for this results in a non-uniform baking job. The oven has to be switched off and the faulty lamp replaced, an operation which hampers production.

In addition, some lamps shatter when burning out, causing glass splinters to be scattered all over the oven and resulting in additional cleaning costs.

Metal-clad tubular heaters operating on the far-infrared principle do not have these shortcomings. They are designed for operation under very severe working conditions and in most cases use a special stainless





Batch oven having hinged side panels and sliding door.

steel for extremely long life. Unlike lamps, they are not damaged by drops of water or paint, by sudden mechanical shocks, by continuous vibration or by over-voltage, and they require far less cleaning than lamps and lamp panels.

As for safety, it is often thought that a metallic heater glowing at about 1,100 to 1,400 F represents a greater fire hazard than an infrared lamp with its relatively cool glass envelope. Just the opposite is true. It is unpredictable when the glass of a lamp is going to break and expose, for a fraction of a second, the filament burning at about 4,000 F.

On the other hand, infrared lamps are definitely superior to metal or ceramic-clad heaters when it is necessary to switch off the heat instantaneously, as in the case of paper mills, where the material comes suddenly to a standstill. In this case, far-infrared heaters (with their lower temperature but higher residual heat) are not so good as infrared lamps, especially high intensity quartz lamps. The same applies to special applications where the short wave near-infrared yields a better penetration through relatively thick layers of certain materials.

Far-infrared heating panels have usually a higher wattage rating than lamp panels of the same size. Fewer far-infrared heating panels have usually a higher wattage rating than lamp panels of the same size. Fewer far-infrared panels are therefore needed for a given kw requirement. This results (in most cases) in lower cost, especially when the less complicated wiring is being considered and also the fact that maintenance of far-infrared panels consist practically of cleaning them from time to time.

Figure shows a standard far-infrared heating element manufactured by CGE. The radiant Calrod element is a hairpin shaped, tubular heater, incoloy sheathed. The helical resistance wire of the element is embedded in magnesia oxide. For ratings and intensities, see table.

The panel suitable for the above heating elements is shown in figure. Two elements are used per panel. The standard panel wattage can therefore be varied between 6 and 10 kw. As all radiant Calrod elements have the same physical dimensions, they can be interchanged if the panel wattage has to be raised or lowered.

The main part of the panel is the reflector, made from electro-brightened, slightly anodized, aluminum sheet. Due to the shape of the reflector (and the position of the heating elements), an almost uniform distribution of infrared radiation is achieved.

The body of the panel contains fibre glass insulation, in order to reduce heat losses and to keep the heat from the Calrod terminals. The terminal box on the rear of the panel contains terminals, lugs and jumpers that allow connections of both heaters either in series or in parallel, depending on the line voltage. It is also possible to control each heating element separately if desired.

The CSA approved panels are light (shipping weight about 39 lb. with two elements) and are 6 ft. long and 9 in. wide.

Some Design Principles for Far-Infrared Ovens

It is nearly always possible to design a far-infrared oven to suit the size and shape of any work component or application. Knowledge and experience are naturally required in order to build an oven for the required wattage so that it may still have a certain reserve. As previously mentioned, the heat transferred to the work by radiation and convection depends on various conditions, such as shape, weight, material, surface and color. In many cases, calculations have to be performed using all the data available. In the case of standard ovens, the wattage can be based on the design data of similar installations. Provision should always be made for future expansion, and one of the main features of radiant Calrod panels is that they are readily installed, yet

Cat. No.	kw	Voltage of Calrod element	Average intensity of radiation, vertical to panel (watts per sq in.)
OX3A2	3	230(x)	7.5
OX4A2	4	230(x)	10
OX5A2	5	230(x)	12
OX3A6	3	287.5(y)	7.5
OX4A6	4	287.5(y)	10
OX5A6	5	287.5(y)	12

(x) For a line voltage of 230 volts, both 230-volt elements are connected in parallel. For a line voltage of 460 volts, both 230-volt elements are connected in series.

(y) For a line voltage of 575 volts (550 volts) both 287.5-volt elements are connected in series.

can easily be removed if the shape or size of the infrared oven has to be altered because of changes in the production program.

As to the actual design of the oven, it is advisable to build it according to the shape of the most important items to be heated. A typical example of this type of oven was designed for curing enamel on small refrigerator cabinets. The oven has the same square shape as the sheet metal boxes going through. Unfortunately, this condition cannot always be met by the design engineer, especially if various shapes and sizes have to be considered. However, far-infrared ovens are not so critical in this respect as lamp ovens, because heated air in the oven always has the tendency to increase the uniformity of the heat transfer process. This is because far-infrared ovens combine the advantages of lamp and convection ovens without having their shortcomings. Sometimes, however, it is useful to rotate the parts on the conveyor hooks while passing through the oven. If the width of the object varies, both oven sides are made movable to allow for the widening of the oven width.

Deciding the length

After the cross-sectional design of the oven has been established, it is important to decide on its length. With nonconveyorized batch ovens, this is determined by the size of the object, whereas with conveyorized installations, the length depends on the conveyor speed and the total heating time, according to the following equation:

$$\text{Oven length (ft)} = \text{conveyor speed (fpm)} \times [\text{heating-up time (min)} + \text{temperature holding time (min)}]$$

The conveyor speed depends entirely on the production requirements, the size of the product and its position on the conveyor hooks. (This is because the size and position govern the distance between the individual parts hung on the conveyor). In about 90% of all applications, it is the manufacturer of the parts who decides on the conveyor speed, since he best knows the types and quantities to be dried or baked per day. Quite often, however, the conveyor speed requested by the manufacturer is too high, for he considers future expansion and production schedules. This, of course, would result in too long an oven, even exceeding the space available.

In this case, it might be necessary to lead the manufacturer back to the conditions prevailing at that time (or in the near future) and to design the oven in such a way that extensions for future production increases can easily be met by adding new sections. It is sometimes advisable to build a relatively shorter oven length, especially if the oven is to be suspended from the ceiling and thus save valuable floor space.

The last part of the equation for oven length consists of the sum of the heating-up time and the temperature holding time. The first depends mainly on the size, weight and shape of the parts. Heavy gauge parts heat up much slower than light gauge products, which usually attain the required temperature instantaneously. The temperature holding time (baking time, curing time) is usually given by the paint or enamel manufacturer, who also specifies the upper and lower temperature limits of the heating process.

The above equation yields the minimum oven length. It is, however, suggested that one or two sections without heaters be added to this length. These sections should be completely enclosed by bright aluminum baffles. This part of the oven (located at the

end of the heated sections), will increase the efficiency of the set-up by slowing down the natural cooling process and thus increasing the "temperature holding zone." If, at a later date, production increases, it is possible to transform this baffled tunnel into a heated section.

The baffled sections should therefore be built with the same shape and length as the heated ones.

It is obvious that relatively higher intensity sections have to be provided for the first part of the conveyorized oven, since the temperature has to be brought up to the range requested for the particular application. Heavy metal objects will need a higher wattage than light-gauge sheet metal or plastic parts.

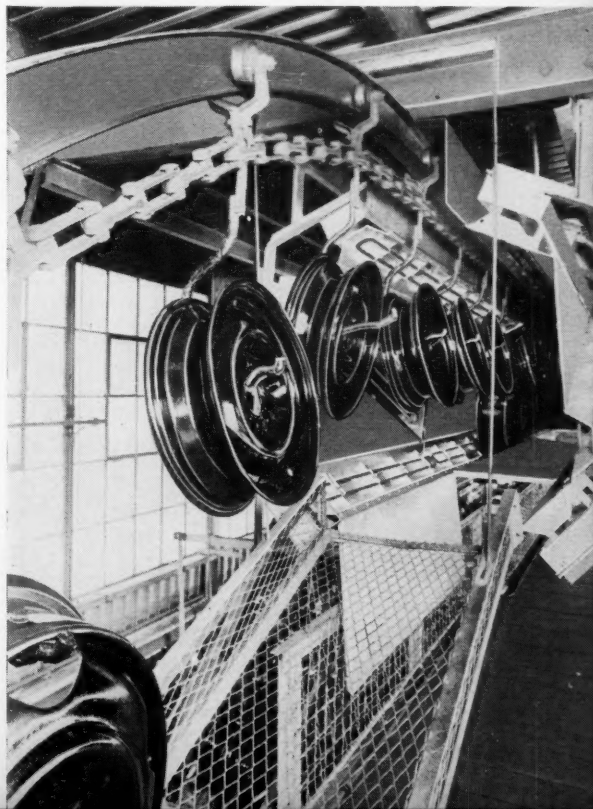
After the heating-up section, the temperature has to be held at the desired range (temperature holding zone). In this part of the oven, the main purpose of the heaters is to replace heat losses mainly due to conduction and convection (including the escape of hot air through the exhaust system).

The main purpose of the exhaust system in bake ovens is to remove so much air and solvent vapors (volatiles) from the oven that the mixture of the remaining volatiles with the air stays safely below the explosive ratio. At least 10,000 cu ft of air at 70 F should be exhausted for 1 U. S. gallon of toluol. An oven evaporating hourly 3 U. S. gallons of this solvent should therefore have an exhaust system removing 30,000 cu ft of air per hour (500 cu ft per min), these volumes being based on an air temperature of 70 F. Other thinners require different exhaust volumes.

The designer of the oven should, in each and every case, determine the minimum exhaust volume. If this has been done and the circuits of the exhaust fan and heaters are interlocked in such a way that the heating elements cannot be operated when the fan is not working, then the main condition for safe operation has

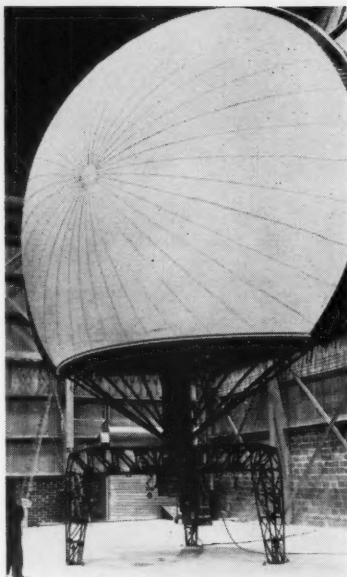
(Continued on page 80)

Calrod oven for baking enamel on car and truck wheels.

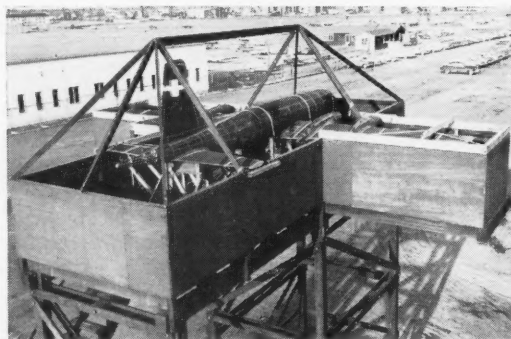
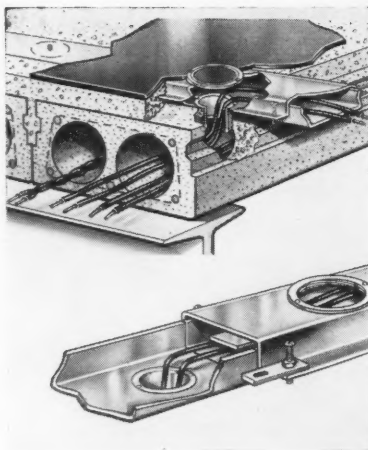


Design news in pictures

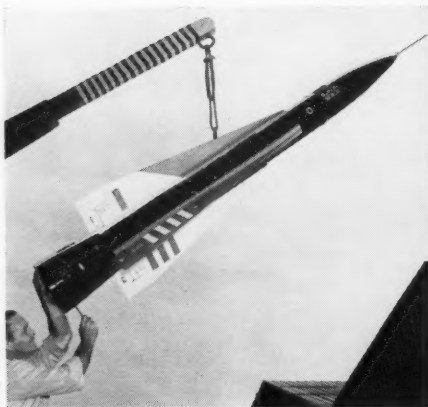
► This lollipop balloon is a revolutionary new radar antenna developed by Westinghouse for Air Force use. It makes mobile high power radar units possible. (212)



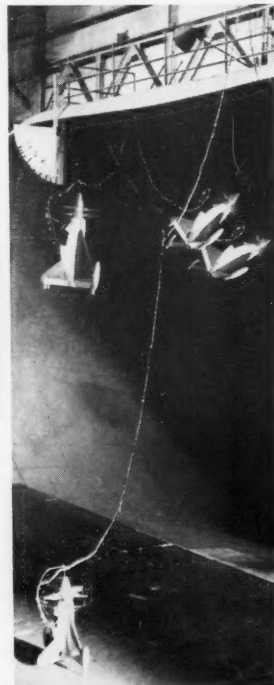
An ingenious way of making use of hollow concrete floor construction by using Conduflor feeder ducts. (213)



▲ One fifth scale model of the CP-107 covered in copper mesh to enable study of the impedance characteristics of the isolated fin HF antenna. (214)



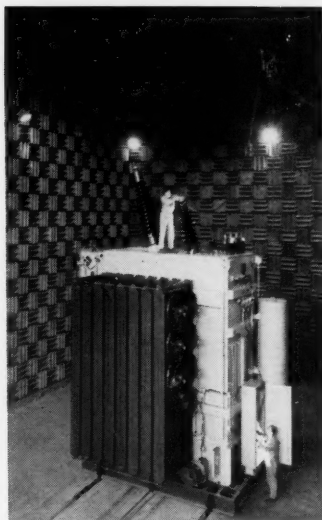
▲ Experimental missile developed by Cornell Aeronautical Laboratories to test its bomber defense missile control system. These have been fired from rocket sleds. (215)



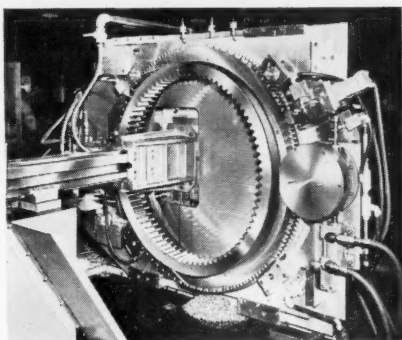
◀ Multiple exposure shot of the Convair XFV-1 taking off, hovering and flying forward in a wind tunnel. (216)

Some modern designs making news today

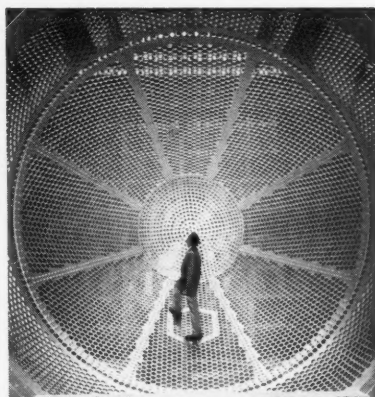
Tiny iron whiskers with tensile strengths as high as 1,900,000 psi are less than an inch long and not as big around as a human hair. Strength of these new crystals is more than 150 times that of ordinary iron crystals. (217)



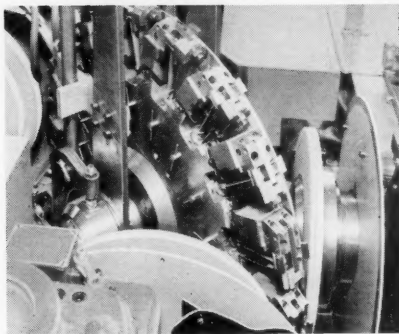
Anechoic vault where sound measurements can be made on equipment weighing more than 400 tons. (218)



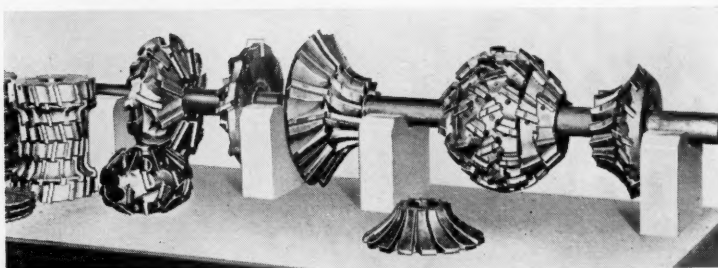
Horizontal broaching machine to speed the cutting of large teeth. It is rated at 15 tons. (219)



Screen in the muffler building at the end of NAA's trisonic wind tunnel. (220)



Three-slide grinder which automatically finishes the curved surfaces of jet engine vane roots. (221)



Milling cutters of wood made up to determine most economical way to manufacture. (222)



Handful of bellows shows the variety in which they can be made.

The master of a thousand applications

Metal bellows have served industry for years. Their uses are legion

"Thin walls
neatly pleated like
an accordion."

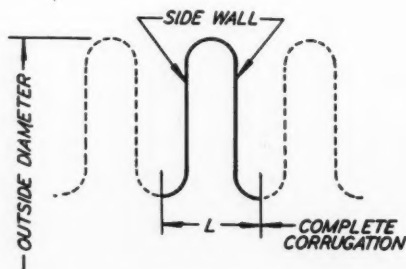


Fig. 1. A complete active corrugation.

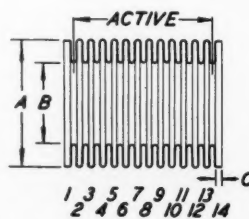


Fig. 2. 14 corrugation unit.

By John W. Dennis ASSISTANT EDITOR

It is more than 50 years since a Tennessee weatherman, searching for a simple way to measure atmospheric pressure, invented for the purpose a metallic bellows.

At the suggestion of a local plumber he applied his invention to the development of an automatic damper for steam boilers which were used in home heating. The name of this young man was Weston M. Fulton; in 1904 he established a firm in Knoxville to produce his seamless metal bellows. For a trade name Fulton chose the name "Sylphon" after the Norse goddess of the atmosphere. This firm is now the Sylphon Division of Robertshaw-Fulton Controls Company.

Fulton's first bellows, soldered out of brass, were extremely unreliable at the best of times. The main source of the trouble rested in the soldered seams which burst under high stress. After several experiments with devices for drawing tubes from flat stock (much as a silversmith builds a cup or bowl from a flat sheet of sterling), Fulton finally perfected a method of producing seamless metal bellows that were both durable and cheap to manufacture.

The bellows are precision-made cylinders whose thin walls have been neatly pleated similar to those of an accordion or folding camera. Once the metal tubes have been corrugated and formed into bellows, they can be expanded and contracted. The bellows are composed of a number of active corrugations with an inactive corrugation at each end. These inactive corrugations are trimmed to receive (or formed integrally to produce) the bellows head or heads.

One complete active corrugation is illustrated in fig. 1. It consists of two sidewalls connected by the curved portions shown. Generally speaking, a 14 corrugation bellows (see fig. 2) would have 12 active and 2 inactive corrugations.

How are bellows made? In one automatic operation, discs of metal are punched out and formed into deep cups. This cup goes through a series of drawing operations which establish the diameter and wall thickness of the tube. The tube can then be trimmed to correct size. Fig. 3 shows the steps involved from the disc to the tube stage.

The final step shown in fig. 3, that is, the forming of the bellows from a tube, can be done in one of two ways. Some bellows are formed hydraulically and others are roll-formed. The process used is determined by the requirements that the finished bellows must meet in actual usage.

First of all, hydraulic forming. Most bellows under 4½ in. outside diameter are formed hydraulically. To produce these bellows, the tube is placed in a forming machine and hydraulic pressure applied inside the tube. This forces it to take the shape of a corrugated die. The

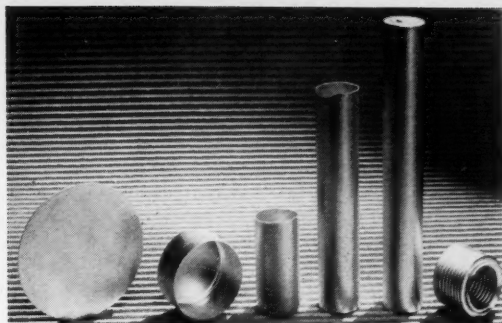
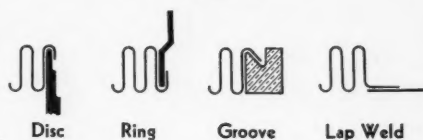


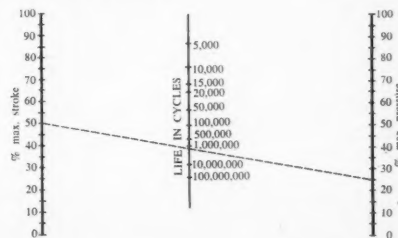
Fig. 3. Stages in manufacture from discs to bellows.

Figure 4.



Nomogram

This chart shows the relation between stroke, pressure and life. It is based on the results of hundreds of tests conducted on various sizes and types of bellows under many different conditions. It affords a method of predicting bellows life expectancy.



Using a straight edge, connect the stroke (expressed as a percentage of the maximum stroke) to the pressure (expressed as a percentage of the maximum pressure). This line intersects the central scale at the probable life.

Example: A 1½-in. OD bellows having 14 active corrugations is to operate making 0.182 in. stroke under 28 psi pressure. What will be its probable life?

Percent of maximum stroke
 $[0.182 \div (0.026 \times 14)] = 50\%$

Percent of maximum pressure
 $[28 \div 112] = 25\%$

A line connecting 50% stroke and 25% pressure intersects the central scale at more than 1,000,000 cycles. This figure is the probable life of the bellows under the conditions stated.

Some applications of seamless metal bellows

Pressure motors

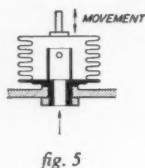


fig. 5

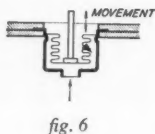


fig. 6

Thermostatic motors

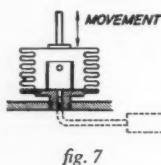


fig. 7

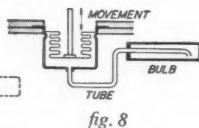


fig. 8

Expansion chamber

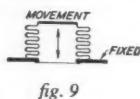


fig. 9

Shaft seal

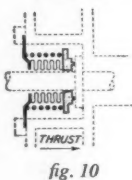


fig. 10

Flexible joint

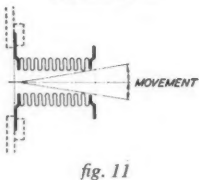


fig. 11

Packless construction

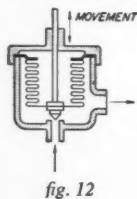


fig. 12

Remote transmission

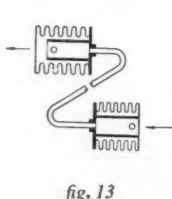


fig. 13

Expansion joint



fig. 14

Bellows assemblies are often employed to convert pressure effects into controlled movement. Pressure may be applied inside the bellows (Fig. 5) or outside the bellows in a cup structure (Fig. 6); the latter being preferred where practical. The floating head is usually provided with a limit stop. Attachments and loading would be provided as required.

Similar to pressure motors above, the pressure being supplied by a vacuum-sealed fill of thermo-sensitive liquid. The thermal effect may be received either on the bellows element direct or at a remote bulb for transmission through flexible tubing. These assembly types are widely used in temperature regulators, etc., where a valve, switch or damper is to be operated in response to temperature changes. (Figs. 7 and 8)

This type of assembly is employed to absorb thermal or pressure expansion. With suitable heads, it would be used to serve as a reservoir for a liquid or gas. Example: Oil reservoir for electrical cable joint. (Fig. 9)

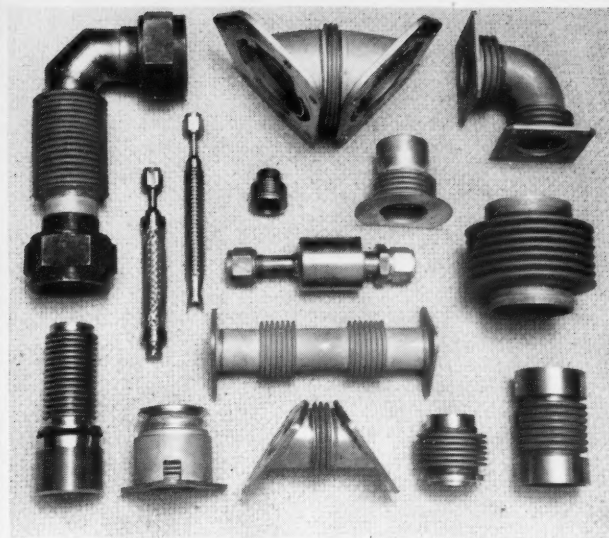
Used to prevent leakage around a revolving shaft. Spring pressure holds nose of seal against shoulder on shaft. Another type used rotates with shaft and seals against a stationary plate. (Fig. 10)

Providing a means to seal a flexible joint or mechanical movement of levers, linkage, etc., against leakage where the movement must be conveyed outside an enclosure. Example: Operating stem of float switches. (Fig. 11)

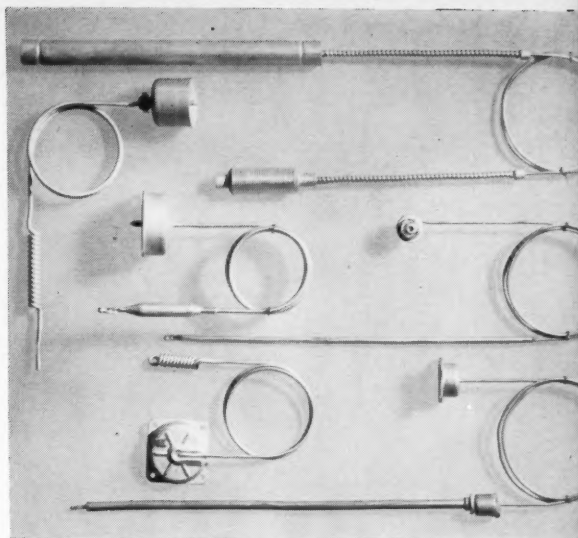
Illustrating packless valve construction. Same principle used to seal stem movement or adjustment in many types of apparatus. (Fig. 12)

Two bellows assemblies joined by a tube for hydraulic transmission of motion or power. With bellows system solid filled under vacuum, linear motion of one bellows is transmitted instantly and in equal degree to remote bellows, both being provided with limit stops. (Fig. 13)

Packless and leakless construction used to absorb thermal expansion of pipe lines carrying steam, water, etc. May be used to absorb vibration and provide flexible connection for other applications. (Fig. 14)



It is often more economical to buy complete bellows assemblies direct from the manufacturers. In most uses



the thin metal end has to be spun over the edge of the head and usually requires delicate welding too.

"Bellows of different materials have different endurance qualities"

inside diameter of the hydraulically formed bellows is substantially the same as that of the tube. Consequently, cold-work is imparted chiefly to the outer bend.

Secondly, roll-forming. By this method, a number of broad corrugations are formed in the tube walls and these are successively deepened and narrowed with suitable rolls. The diameter of the tube used in making the rolled bellows is less than the outside (and greater than the inside) diameter of the finished bellows. Cold-work is imparted to both inner and outer bends, resulting in bellows that have elastic characteristics specially suited to many applications.

Multi-ply bellows are produced by placing one close-fitting tube inside another and then forming the corrugations in the same manner as for the single-ply bellows. These multi-ply bellows give satisfactory resistance to higher pressures without too much sacrifice in flexibility.

Heads are usually provided with a rounded edge about 3/64 in. thick over which the bellows' end is spun and then soldered. A shoulder or offset on the head confines the flow of solder to the immediate vicinity of the connection. Some of the various types of joint are shown in fig. 4.

Bellows made from different metals have different endurance qualities. Those most commonly used are brass, phosphor bronze, beryllium copper, monel and stainless steel.

The strength of the metal, whether annealed, cold-worked or heat-treated, also affects the endurance quality of a bellows. Cold-working metal is effective in increasing its resistance to repeated stresses.

As for the uses of seamless bellows, they are legion. First designed as automatic damper regulators for household furnaces, they are now used to make home appliances more automatic, easier to build and easier to operate. Fabricated from special steel alloys, they are used in regulators and as the packless feature of valves

at the Oak Ridge atom plant. They are being used for oxygen regulators in high altitude aircraft. In these aircraft, bellows ensure correct fuel and air mixtures by counteracting changing air pressures. As integral parts of many bomb sights, metal bellows help to put explosives "on target."

A look at figs. 5 to 14 will show at a glance some of the many applications of seamless metal bellows.

When designing devices which will use bellows, the following conditions must be remembered:

(a) Overstressing a bellows may deform its corrugations and reduce its endurance limit; consequently, if a bellows is severely overstressed before it is installed, its life will be impaired even though the stresses encountered in service may be quite low.

(b) The nature of the stroke may also affect the life. Sudden shocks induce high localized stresses and result in shorter life.

(c) In general, the life of a bellows is independent of the speed at which it is operated, but at very high speeds a destructive wave of vibration may be set up which will materially shorten the life.

(d) The action of corrosive agents may so weaken the structure that the life of a bellows will be greatly shortened.

(e) Temperature is also a factor. If the burrs of a brass bellows are spun over the head and the joint sealed with 50-50 solder, the assembly will withstand a temperature of 300F. For high temperatures, other metals are used and special head attachment methods employed.

On p. 61 is a nomogram which shows the relationship between stroke, life and pressure.

Bellows are playing a part in office buildings, railroad cars, diesel engines, the family auto, in jet aircraft and in atom plants throughout the country. In heavy industry they are used to control the flow of liquids. ★

New products & materials



Entire disc is cast in a single piece.

Wafer valve disc

An unusual wafer valve disc, weighing about 1700 lb., was recently cast by the Buffalo foundry of **Allegheny Ludlum Steel Corporation** for the W. S. Rockwell Company. The entire valve disc had to be cast in a single piece and the center of each side had to be cored or kept hollow. This was done by keeping the mid-portion of the valve solid and coring each side. The metal sections (or skins) of the valve are $\frac{3}{4}$ in. thick and are made of type 304 stainless steel. The valve (which has a diameter of 48 in.) will be used in the circulating water system which passes highly corrosive salt water. Stainless steel was specified to prevent corrosion, for this would hinder the tight closure of the valve. The valve is designed for 25 psi pressure. (200)

High Speed Camera

A camera capable of a speed of 100,000 frames a second that will make possible the study of high-speed phenomena (otherwise not observable) is announced by the **General Electric Research Laboratory**. The camera creates an image consisting of a pattern of dots. It then records the next image by shifting the second pattern of dots just far enough to avoid landing on top of the first. The relatively small distance that the film has to travel to provide this motion makes the high-speed camera possible. (201)

Vacuum gauge

A single meter type vacuum gauge with a range of 0 to 100 microns Hg full scale, is announced by **Hastings-Raydist, Inc.**

The new instrument has a 4 in. indicating meter and a knife-edge pointer for direct reading on a logarithmic mirror meter scale. Half scale on the dial

face is 15 microns, providing excellent readability for low micron measurements. The instrument is accurate throughout the entire range. (202)

Ladder design

For the first time in Canada, **R. D. Werner Co. (Canada) Ltd.** have introduced what they call "the strongest rung attachment in ladder history." This new rung (called Alflo), is locked hydraulically into the ladder side rails by a patented process which is a distinct advance in ladder engineering, developed, perfected and tested by the company's research and engineering staff.

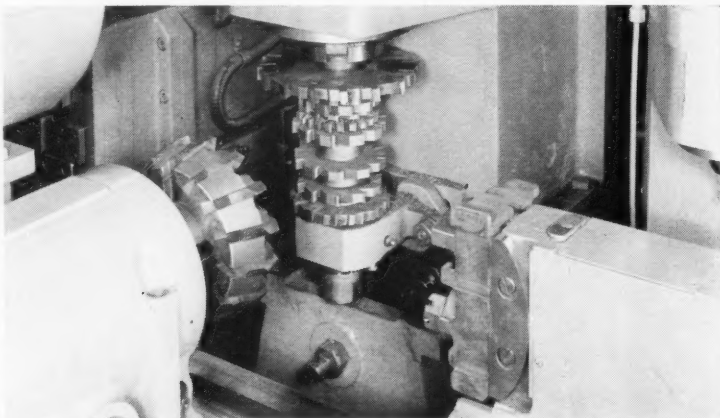
Now being installed on the firm's line

of aluminum straight and extension ladders, the new rung is accompanied by improved engineering throughout the ladders. Extruded side rail channels have been redesigned to insure maximum strength at minimum weight per foot. The new rails now give easier manual handling and smoother action between interlocking side rails. (203)

Anodizing rack

An all-titanium rack, with a high degree of adjustability to adapt it to different types of anodizing jobs, is available from **Robe, Incorporated**.

The racks are made of titanium Z sections, spot welded to a titanium base section to provide a series of grooves. In these grooves titanium "fingers" (which act as contact points) can be moved and fixed in any position. The design makes it possible to anodize parts of widely varying shape and size. (204)



Close-up of part of the special purpose machine built by **Standard-Modern Tool**. Milling head (at left) faces two mounting surfaces while the multi-head cutter (at right) gang mills thirteen surfaces at the same time. (205)



A recent development at **Dow Corning** is a silicone rubber with glass-like transparency. It shows excellent promise as a centre layer in safety glass windshields as it retains full clarity and strength from -65 to 350°F . (206)

(Continued on page 96)

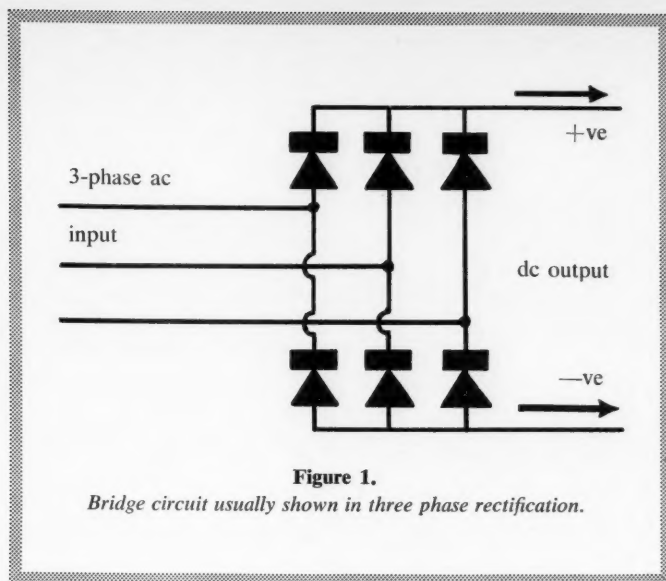


Figure 1.

Bridge circuit usually shown in three phase rectification.

3-phase rectification — what happens?

Textbooks on the subject are mostly vague. They draw voltage curves of the three phases and invert the lower halves without explanation

By W. H. Sheppard, P.Eng.

AVRO AIRCRAFT

In considering three-phase rectification, the bridge circuit of fig. 1 is usually shown. Since the voltage in each line rises and falls three times per cycle, it might at first appear that three peaks per cycle are being passed to the positive whereas actually, in a closed circuit, there are six. Recognized textbooks on the subject are mostly vague; they usually dismiss the paradox by drawing voltage curves of the three phases and inverting the lower halves of each to give a total of six peaks, without explaining how they are obtained.

To understand the phenomenon, consider first the voltage in each of the three busbars of an a-c mains (or from a generator with earthed starpoint) rising and falling sinusoidally, as indicated in fig. 2 (c). This may be regarded as the projection of the three rotating vectors shown in fig. 2 (a). These are **phase** voltages. The voltages between lines (the **line** voltages) are equal to $\sqrt{3}$ times the phase voltages and lag (or lead) the phase voltages by 30 electrical degrees, as indicated in fig. 2 (b). Referring now to the rectifier output, the voltage difference between the positive and negative at any instant is the greatest difference between any pair of voltages, as indicated by the vertical double-ended arrow in fig. 2 (c). This difference is, in fact, equal to the

greatest **line** voltage, which paradoxically is lowest when the phase voltages are at a maximum. By projecting to the centre line as a common base line as shown in fig. 3 (c), the voltage output **difference** graph is obtained. To give a strict mathematical reasoning, let the two voltages be represented by:

$$\begin{aligned} v_1 &= V \sin \theta \\ v_2 &= V \sin (\theta - 120) \\ v &= V [\sin \theta - \sin (\theta - 120)] \\ &= 2V \cos (\theta - 60) \sin 60 \\ &= \sqrt{3} V \cos (\theta - 60) \\ &= \sqrt{3} V \sin (\theta + 30) \end{aligned}$$

This is the line voltage, displaced from the phase voltage by 30 electrical degrees. It may be represented by the line voltage vectors considered only in the top 60 deg. as shown in fig. 3 (a).

It should be clearly understood that, in the above case, the voltage output is a voltage difference and if derived from any stable source (that is, with earthed star point) the positive and negative outputs each rise

and fall with only three peaks per cycle (as indicated by the extreme top and bottom lines of fig. 2 (c)). The voltage difference rises to 6 peaks per cycle, as in fig. 3 (c), the peaks being intermediately spaced between those of the positive and negative. For this reason, an earthed negative, earth return or earthed busbar must never be used in conjunction with raw a-c mains (or other stable source) unless a transformer is inserted in the a-c output. Otherwise the negative side of the d-c will be short-circuited and the positive side will tend to give three peaks per cycle at phase voltage. On the other hand, if isolated busbars are being fed (or other closed circuit, for example, battery charging) full benefit will be obtained. It should be realized that current can only be obtained from the greatest output voltage difference, so that at any one instant only one rectifier is being used on each side of the positive and negative. The economy is much greater than might be expected, however, since the elements can be made relatively small as they do not heat up so much as for single phase. A three-phase rectifier gives comparatively smooth output; the dry plate type has the advantage that it has no moving parts, is reliable and requires practically no maintenance.

Now consider that a generator with isolated star point is used to supply a-c or alternatively, a transformer is inserted in the input to the rectifier, the negative output of the latter being earthed or considered at earth potential. The output will be the same as previously, but in this case the potential of each supply lead will at any instant be zero or at positive potential. Each phase rises in turn to a double peak and the star point rises

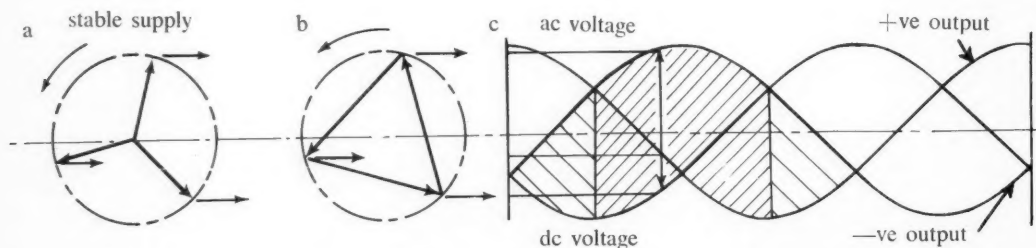
three times per cycle (fig. 3 (c)). This may be regarded as the projection of the voltage vector pattern rotating on the centre-line as a "floor," as in fig. 3 (b), and may be represented by phase voltage vectors considered only in the top 120 deg., as shown in fig. 3 (a). It can be proved that the total variation of the star point is 1/3 the lowest d-c output. It will be observed also that the starpoint voltage graph is an inversion of the combined a-c voltage graph below the centre line or a displacement of that above it, while the phase voltage graph (shown shaded in fig. 3 (c)) is a projection of that part of one wave form considered from the bottom of the combined phase graph.

Regarding optimum voltage

With regard to optimum d-c busbar voltage, for pure rectified output as shown in fig. 3 (c), this should be equal to the lowest d-c output. In practice, however, since some smoothing takes place or may be introduced, it may be satisfactory to approach the RMS value, which is 0.966 the maximum.

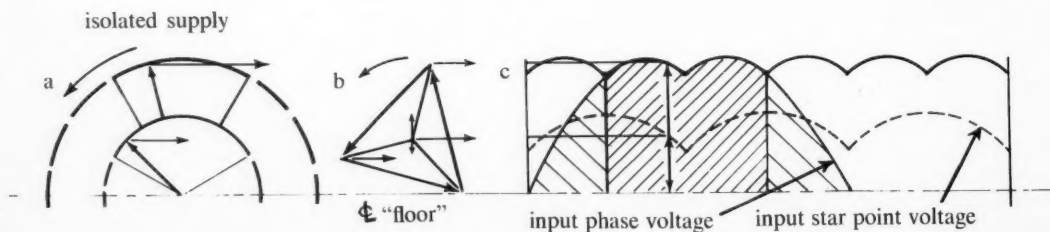
Max. d-c output	= Input peak line voltage.
Lowest d-c	= $0.866 \times \text{max. d-c}$
Max. d-c	= $1.155 \times \text{min. d-c}$
Variation	= $0.104 \times \text{max.} = 0.155 \times \text{min.}$

In short, rectified 3-phase current must be isolated from its source and may be regarded as derived from line voltages with characteristics as above. ★



Figs. 2(a), (b) and (c). The voltages between lines lag (or lead) the phase voltages by 30 electrical degrees.

In fact, 6 peaks per cycle pass to the positive in a closed circuit



This applies also to stable supply with respect to output voltage difference only

Figs. 3(a), (b) and (c). Voltage difference rises to 6 peaks per cycle, spaced between positive and negative.

Design



Engineering



show




& conference



Thirty-three top design engineers will lead discussions at the
conference which will be held
during the first three days (May 20, 21 and 22) of the show

The following are abstracts from most of the papers to be read



Monday, May 20, 10 a.m.

Procedures in developing new designs. A question-and-answer panel.
There will be no abstracts.

Tuesday, May 21, 9.30 a.m.

Three concurrent sessions

Mechanical session

New developments in design and application of gearing

DARLE W. DUDLEY

Progress and developments in the art of gear design will be related to present day and future requirements. The use of prime and derating factors will be discussed. Application of indexes (K-factor, unit load, and Q-factor) for estimating gear sizes. Examples of high-speed gearing, lightweight gears and close-tolerance gears will be shown. Automation factors will be discussed.

New developments in design and application of cams

HAROLD A. ROTHBART

Acceleration limits, choice of cam contour, required profile accuracy and manufacturing methods have to be known to design cams for high-speed mechanisms and industrial machinery. Comparisons between the actual and theoretical acceleration curves will be shown. A dynamic design limit has been established as a guide to the development of new machines. Summary of both theoretical and practical considerations for high-speed cam follower performance.

Materials session

Metallic materials

CHARLES R. SIMCOE

Major developments, including new metals and alloys for high-temperature use; new metals and alloys where the strength-weight ratio is the most important factor; new combinations of metals, such as honeycomb-sandwich construction; and new processes for improving the properties of metals and alloys. Materials include titanium, zirconium, molybdenum, alloys of aluminum and magnesium, and nodular ductile iron. Processes are vacuum melting and casting, chem-milling and others.

Ceramics and refractory materials

JOHN H. KOENIG AND EDWARD J. SMOKE

A resumé of recent technical developments in the field of ceramics will be presented. It will include: refractories and refractory coatings; cermets; enamels; glass; dielectrics; porcelain and mechanical ceramics, along with discussion of engineering and service properties, principal and potential areas of application.

Electrical session

Selecting motors with new NEMA frame sizes

EARL C. BARNES

Presented and discussed are some of the significant changes in ac and dc motors. Application of these new motors to motor-driven equipment can improve performance, economies in first cost and operation, appearance, size and other benefits. Electrical and mechanical features will be discussed.

Static switching devices

DR. ROBERT A. MATHIAS

Basic logic functions of AND, OR and NOT will be described and related to relay switching circuits. Static logic power supplies, sensing and input devices, and output power amplifiers will be discussed and related to the relative cost factors of each. A description of the general procedure used for static switching systems will be given.

Wednesday, May 22, 9.30 a.m.

Three concurrent sessions

Mechanical session

Designing for easier machining, handling and assembly

KURT O. TECH

Design of a part can affect the product cost through the handling, storing and assembling of the part. The shape of components affects the material handling and storage. Location of screws may make automatic simultaneous multiple assembly impossible. Parts designed for assembly are usually easy to store, handle and machine. These problems should be considered early in any design project and carry equal weight with its function and styling.

Hopper feeding

FLOYD E. SMITH

Basic characteristics of various hopper feeds obtainable for installation on automatic machines. Proper type of feed determined by rate of feed, general toolability, area for installation. Advantages and disadvantages of each type will be given. General over-all cost of hopper installations and amortization compared to direct labor costs.

Materials session

Plastics and rubbers

WYMAN GOSS

Plastic materials are replacing older materials of construction in many fields. Ten different plastic materials or copolymers are being used in the automotive industry alone in electrical systems, fuel systems, transmissions, body, running gears, engines and accessories. Vinyls, styrenes, polystyrenes and phenolics are other resins that are being used to produce some 4 billion pounds of products. New applications for the older plastics, and new resins are being developed almost daily.

Coatings and finishes

H. J. REINDL

Three general classes of coating and finishing material are to be discussed: organic coatings; metallic coatings, conversion coatings. Organic coatings include the varnishes and enamels. New coatings are the epoxy, Hypalon and polyurethane types. Metallic coatings are high vacuum metallizing, electrically conductive coatings, tungsten carbide and others. Conversion coatings, such as oxides on aluminum, phosphate and chromate, are but a few of the types to be presented.

Electrical session

Numerical control for machinery

CLAUDE D. COFFIN

Factors that determine the economy of applying numerical controls to machines. Factors include: physical size of controls, complexity, maintenance, type of data, methods used and the preparation of records. Also discussed are the types of machine for which numerical control is of doubtful value or even economically and technically unsound. Resumé of the basic types of machinery control for determining whether or not numerical controls will be feasible.

Designing machine tools for automatic controls

C. B. SUNG

It is often desirable, for maximum economy, to design for high performance. Various considerations for adequate dynamic performance are discussed. Included are the nature of drive units, machine structure, friction, backlash, load disturbances and feedback instrumentation. Although considerations are for machine tools, most are applicable to other types of machines designed for automatic control.

Exhibitor

Booth No.

A

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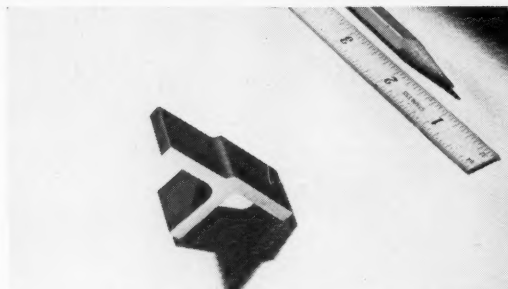
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Ideas round-up

Extrusion saved the manufacturer 75% of machining time

At the Watervliet (N. Y.) works of **Allegheny Ludlum Steel Corporation** a steel extrusion is now being turned out that saves the manufacturer 75% in machining time. This airframe section (made of SAE 8630 carbon steel) is used in fuselage stringers. Previously the piece was made of bar stock and a lot of material had to be machined off. The smallness of the piece and the material used makes it hard to extrude. A 25-sq.-in. billet is squeezed into a 0.4-sq.-in. T-section. Production speeds run up to 45 mph as the extruded shape leaves the press.

The billet is extruded at temperatures of about 2,250 F to a thickness of 0.140 in. at a pressure of 150,000 psi. The extruded piece is made in bars 25 ft long and then cut to size. (223)

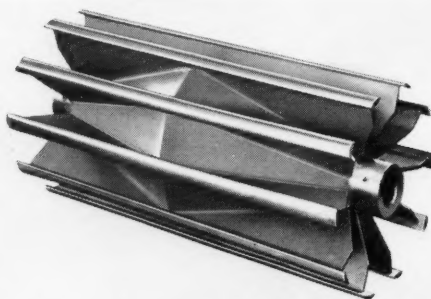


Cross section of extrusion in SAE 8630 carbon steel.

Pulley that can handle sticky or abrasive materials

The use of a slatted pulley is recommended when the material to be handled is abrasive (or sticky) because it prevents such materials from lodging between the belt and the pulley itself. If a conventional pulley were used under the same conditions, the material to be handled could build up in this way and cause the belt to run off the pulley or cause serious damage to the belt.

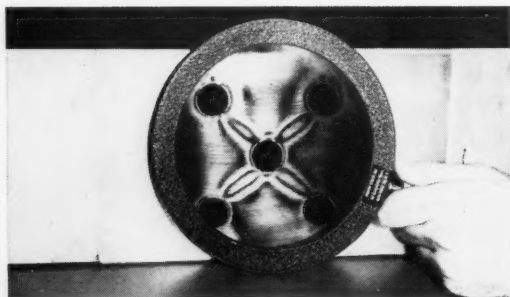
The design of the **Jeffery Manufacturing Co. Ltd.** slatted pulley prevents this type of trouble because the oval bars, placed horizontally across the outside diameter, clean themselves and the back of the belts. The cone-shaped centre allows the material to be carried off on its outer edges. Further features are the wide oval cross bars that give good belt traction and the rounded edges that prevent the belt from being gouged. The fact that they are crowned provides good belt alignment. The oscillation set up by this pulley (be-



Small diameter pulley for use on vertical take-ups.

cause it is not a cylinder type of unit) is another feature that assists in cleaning the belt. (224)

A complete color picture of strain distribution at a glance



The meter placed against a dural specimen in tension.

Photo Stress is a method which uses conventional photoelastic methods for the experimental stress analysis of actual full-size structures or components made of metal, concrete, wood, glass, plastic, rubber, stone (and other structural materials) regardless of size or shape. It eliminates the plastic model of the part formerly required.

The difference between the method and other conventional photoelastic techniques is, first, that the transparent plastic is bonded to the actual part and strains are determined under actual test conditions. Secondly, it is both quantitative (in terms of micro-inches per in. strain) and qualitative, because it shows the direction and magnitude of the principal strains.

It can be used both statically and dynamically in de-

termining the strength of structures in service and it combines both optical and electronic methods for instantly locating (and accurately evaluating) the regions of maximum strain.

It can be used at temperatures ranging from -67°F to $+284^{\circ}\text{F}$ and when immersed in such liquids as water, salt water, oil and gasoline.

Basically, the PhotoStress process (Tatnall Measuring Systems Co.) coats the part or structure to be stress-analyzed with a thin layer of a special transparent photoelastic plastic. When a load is applied, strains are transmitted to the plastic coating which then become doubly

refractive. This change is directly proportional to the intensity of stress.

Developed by Dr. Felix Zandman (a French engineer) the process uses both liquid and strips of photoelastic material which differ considerably in their characteristics and use. The flat strips can be shaped to fit any simple contour, while the liquid plastic is best for the stress analysis of very small parts and complex shapes.

Under any type of loading the plastic coating affords a complete color picture of the strain distribution of its entire surface and highlights areas of stress. (225)

35-ft. ladder that one man can handle

A mobile ladder, made by Magline of Canada Ltd., was designed to provide an economical, mobile, convenient and versatile method of servicing lights and other overhead objects or areas. It was particularly important to keep the collapsed size as small as possible and to make the ladder suitable for use by one man.

Fig. 1 shows the ladder in fully collapsed position, being wheeled into location. The ladder is easily moved by one man, since it weighs only 170 lb. complete and is mounted on swivelling casters at the steering end. When fully closed, the storage space required is 20 ft. x 37 in. x 30 in. The outboard end of the base consists of two members which are cross connected. These are swung out and locked in the spread position. In

the fully erected position, the handle and support at the upper end acts as a safety bracket and there is an extra wide step located for working convenience. The ladder (extension ladder) can be elevated or lowered in the regular manner. It is possible to move the entire ladder from place to place with a man in working position at the top of the ladder. One man at the bottom can quite easily move the entire equipment even with the workman in place.

The ladder base area is such that the unit is quite stable, even with the ladder extended to 35 ft. No tools are required for erection and the unit can be completely extended in about four minutes.

The ladder is removable from the base and can be used independently if required. (226)



Fig. 1. Fully collapsed ladder wheeled onto location.

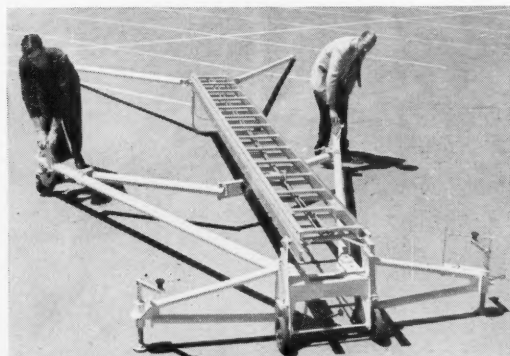


Fig. 2. Cross connected members swung into position.



Fig. 3. The fully erected ladder can be moved easily.

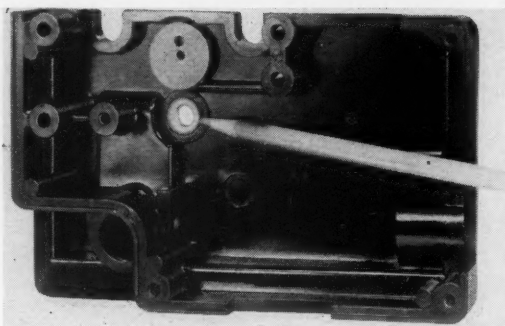
This nylon insert solved a bearing problem

A molding technique involving a nylon insert in a phenolic part has solved some thorny design and production problems for a new automatic ice maker.

This machine, the first of its kind, freezes ice cubes, stores them in a container and automatically replenishes them as they are used. One of the reasons for its successful operation is the ice-ejecting arm that sweeps the newly frozen cubes out of the mold and into a tray. This arm requires an exceedingly strong bearing, (and one which must also be self-lubricating), as otherwise the oil would contaminate the ice. What is more, the bond between the bearing and the phenolic block must be so secure that it will never loosen, even under severe temperature in use.

The material selected for the bearing was nylon, because of its particular properties. However, mechanical assembly of the nylon bearing with the phenolic block had to be eliminated, because of the difficulty of obtaining a good bond and the cost involved.

The research laboratory at **Chicago Molded Products Corp.** (the custom molder of the phenolic part),



Pencil points out nylon bearing moulded into position.

was assigned the job of discovering how to mold the nylon bearing into the phenolic. This was like mixing fire and ice, for phenolic is compression molded at high temperature and pressure and nylon is a thermosetting plastic, which softens at low heat. (227)

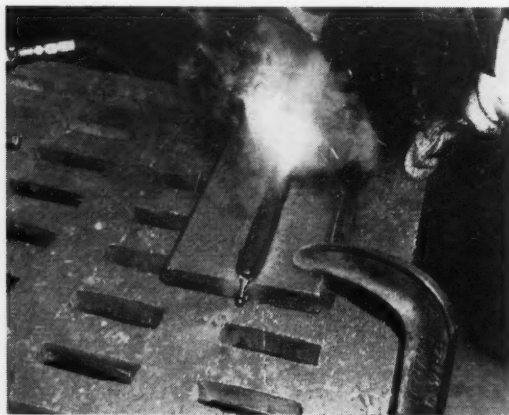
Welding speeds as much as 100% greater, costs are cut too

For many years, steel fabricators have searched for a process with the versatility of covered electrode welding and the high deposition rates of submerged-arc welding. While several methods have been tried in attempts to fill this need, Unionarc welding (**Linde Air Products Ltd.**) shows promise of meeting these requirements.

It is a semi-automatic metal arc welding process, using a continuously fed bare wire, powdered magnetic flux and carbon dioxide gas. The flux is carried to the welding nozzle by the carbon dioxide gas and surrounds the welding wire as it is fed from the contact tip of the torch. When welding current is flowing, a magnetic field is established around the extended portion of the

welding wire. The flux is attracted toward the exposed wire and coats it. As the wire is directed into the weld puddle, the flux melts, refining the weld metal and shielding it from atmospheric contamination. The carbon dioxide flowing from the torch nozzle also helps to shield the molten metal and the arc. This open arc characteristic of the method permits excellent visibility of the weld zone.

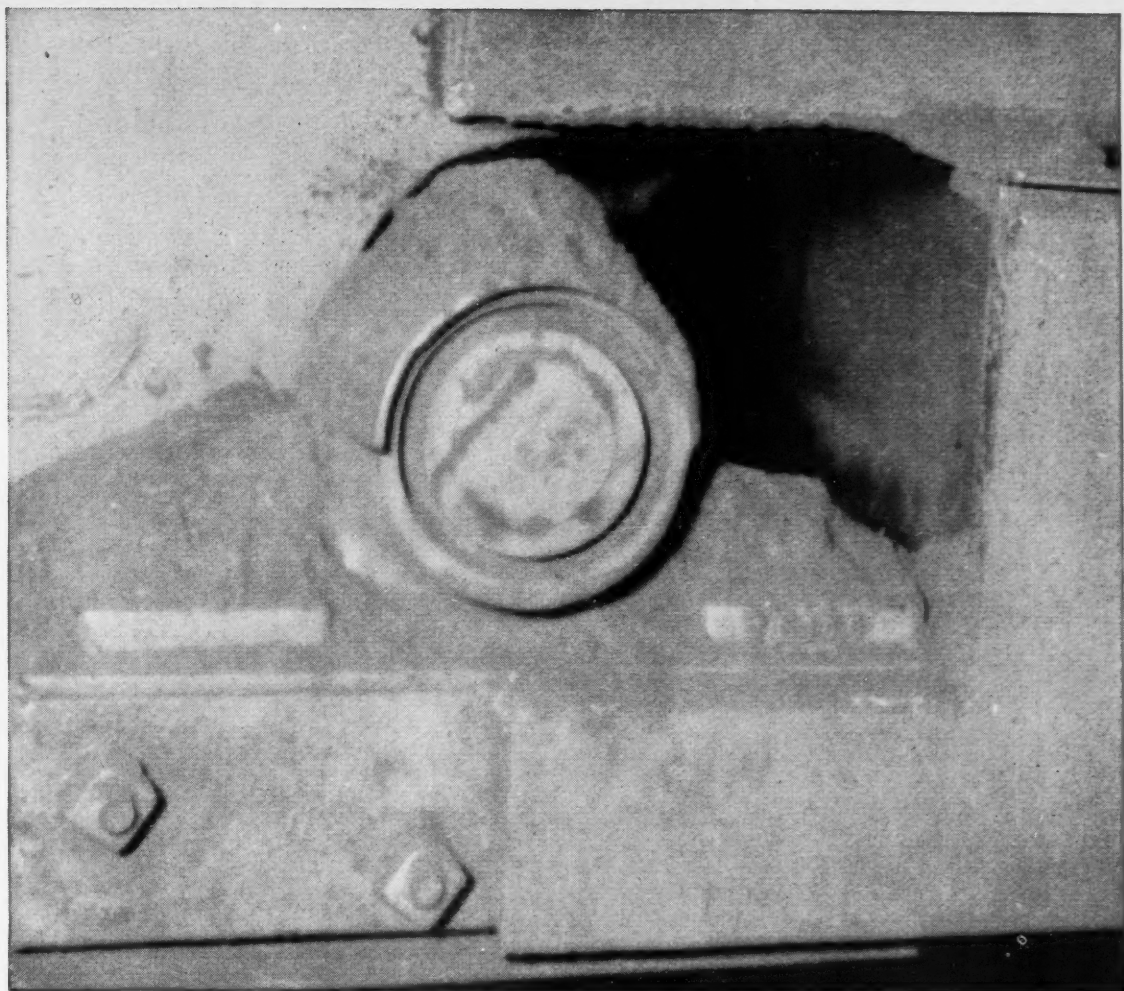
Welds with this visible-arc process can be made manually in flat, horizontal, vertical or overhead positions with speed, economy and quality. Welding speeds are 50 to 100% greater and total welding costs between 20 and 50% less than those obtained with covered electrodes. Such welding produces high-quality welds,



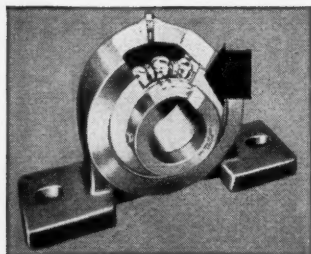
Slag begins rising even before worker completes weld.



As weld is cooling, slag rise becomes more apparent.



Abrasive sand everywhere... outside this Fafnir Transmission Unit



The arrow on the cut-away diagram points to the reason why this Fafnir Ball Bearing Power Transmission Unit excludes dirt and contaminants so effectively. It's Fafnir's efficient labyrinth type seal which effectively retains the factory-packed lubricants while its external slinger throws off foreign materials.

WHETHER or not your machines operate under conditions as rugged as this belt conveyor installation does, the efficient seals and many other features of Fafnir Ball Bearing Power Transmission Units offer outstanding advantages.

Take the Fafnir-developed "Self-Locking" collar, for example. It eliminates shaft shoulders, machinery, adapters, sleeves and lock washers... locks and unlocks with an easy "twist of the wrist." This locking collar also acts to keep the Fafnir bearings firmly in place because it becomes tighter with shaft rotation—yet this collar can easily be disengaged when required.

The entire unit may be mounted in any direction, because the compact, one-piece housing supports the bear-

ing over its entire circumference.

United Steel offers a wide range of types for both machine or power transmission applications—as original equipment or replacements. Catalogue, or the services of one of our field engineers available on request. Dodge Manufacturing Division, United Steel Corporation Limited, 58 Pelham Avenue, Toronto 9, Ont.



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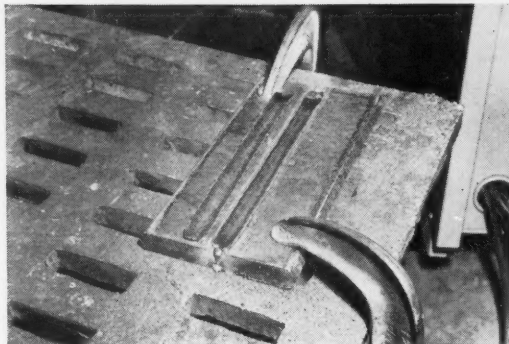
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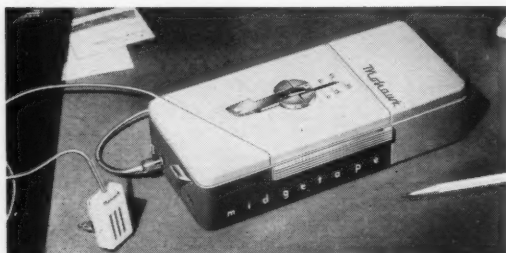
even when moderate amounts of rust, scale and moisture are present, as well as when there are minor gaps. Welds in carbon steel develop an ultimate tensile strength of 75,000 to 85,000 psi and a yield strength of 65,000 to 70,000 psi.

Welds are characterized by soundness and a minimum of undercutting. Constituents of the flux lower the surface tension of the weld puddle, improving weld surface contour. At the same time, the flux thermally insulates the weld metal from the atmosphere, thus lowering its cooling rate. The thin skin of fused flux comes off easily. In addition, Unionarc welding provides greater and more uniform weld penetration than that obtained with covered electrodes. Flux flow and weld penetration can be adjusted to meet joint requirements and welding limitations. (228)



The fused flux removes easily. It is at the left of weld.

Private ear for the private eye



Tape recorder is only slightly longer than a pencil.

A battery-operated, pocket-size tape recorder makes it possible (figuratively speaking) to have a secretary in your pocket.

This recorder (the Midgetape) is manufactured by Mohawk Business Machines Corp.

The Midgetape will record and play back anywhere. It weighs only 2¾ lb and measures 1⅞ in deep x

3⅞ in. wide x 8½ in. long. The batteries are of the hearing-aid type. The dual track magnetic tape is contained in handy aluminum cartridges (the size of cigarette packs) each sufficient for a 60 min recording. The tape can be used 300,000 times, because the old recording is automatically erased as a new one is made. The smallness and lightness have been made possible by using sub-miniature tubes, a printed circuit and an aluminum case. The Midgetape's crystal microphone is the size of a postage stamp, and recordings can be played through its dime-size earphone or an ac/dc amplifier.

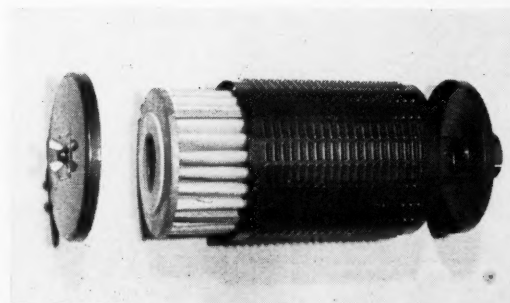
It should be a boon to travelling business executives and engineers who want to record the details of memos and letters immediately, wherever they may be. The tape cartridges are easily mailed to home offices where any secretary can transcribe them.

Several accessories are available, one of which is a telephone induction coil which snaps on the ear piece of any telephone, so that it is possible to record both ends of a telephone conversation. (229)

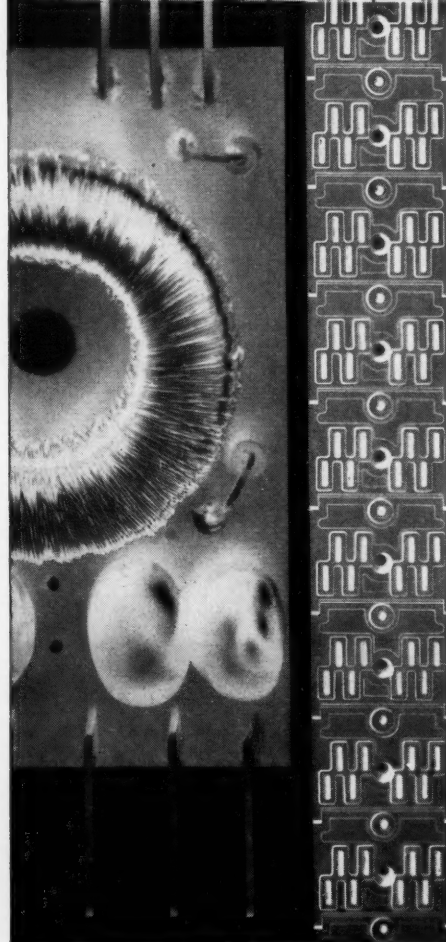
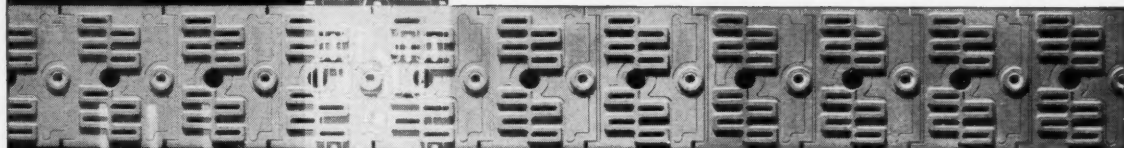
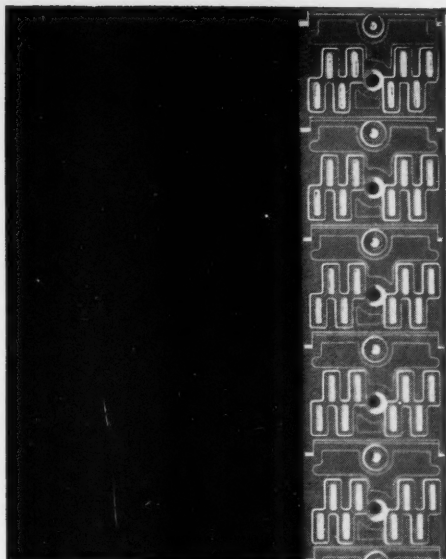
Filter that will catch the tiniest particles

The harmful effects resulting from the entry of dust or sand into the bearing and moving parts of machinery are well known, but sufficient attention is often not given to the prevention of engine wear from this cause. Reliance on such mechanical expedients as the reduction of clearances or the fitting of gauze covers is, in the long run, unsatisfactory, because of the minute size of the wear-inducing dust particles.

Carefully calibrated tests with varying combinations of engine filter-air, lubricating oil and fuel show that it is the very small particles of dust (just able to span the oil film on the internal working surfaces) that cause most of the damage from wear. It is believed that the larger particles pass out through the exhaust or are deposited in the sludge accumulations in the engine



Total area of the filter is 200 times the area of inlet.



THIS IS **CYPAK** *for more flexible industrial control*

In the flexibility of CYPAK lies the challenge to throw out mechanical relay limitations and simplify control for more automated production.

For example, CYPAK systems employ just four different component panels. They provide, in the most practical form, the four basic logic functions of computer science. With infinite combinations of these panels you can direct, far more simply, a greater range of equipment operations.

Because the magnetic "make and break" of CYPAK circuits has no moving parts, it is five times faster than mechanical relays. It's the basic reason for CYPAK flexibility in handling control signals.

In addition, CYPAK systems are designed for physical flexibility. A common power channel is the backbone of each system. Into it CYPAK elements are *plugged in, locked in*, and signal terminals joined. In this manner, the system is easily expanded or replacements made after installation.

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57 A 200

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sump. On the other hand, abrasive particles less than one micron in size cannot span the oil film and may be regarded as harmless.

The standard **Vokes** Microvee dry fabric air filter uses a special fabric mounted on wire gauze, folded into a star shape.

The total area of the filtering surface is about 200 times the area of the intake opening. The air therefore passes through the filtering medium at less than 1/200 of its normal velocity. Assuming that the air is passing into the engine at 200 fpm, it will pass through the fabric at only 1 fpm. The heavy dust particles never reach the louvers of the filter case, but fall by gravity; only the fine foreign matter reaches the fabric. This does not, however, drive into the fabric (to cause a choking effect) but merely flows gently

onto the fabric surface. The vibration of a machine is sufficient to cause these particles of dirt to fall off, so that there is no great accumulation of foreign matter.

A new engine is as efficient as skill, design, materials and manufacture can make it. As soon as it goes into service, dust and grit enter the air intake, mix with the oil and cause rapid wear. Manufacturers therefore recommend changing the oil in the crankcase at frequent intervals, but before this foreign matter can reach the crankcase it must first pass through the piston rings and the cylinder, wearing them by its abrasive action.

Microvee filters completely remove from the air supply all foreign matter of a harmful nature, so that the oil does not become contaminated and can therefore be used far longer with safety. (230)

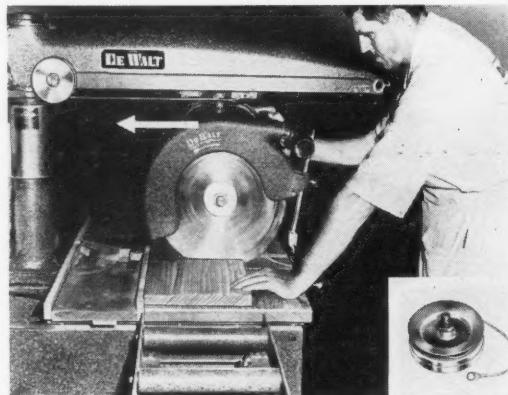
Spring return with unusual features

Positive, safe retraction of potentially dangerous tool heads can be provided by the Spir-ator safety return device just introduced by the **Hunter Spring Company**. An unusual feature of the device is that (unlike conventional spring-actuated mechanisms) it exhibits no excessive build-up of the restraining force, despite very long extension.

The self-contained standard unit consists of a special spring with a fully enclosed housing, a cable reel, cable and a threaded mounting stud. A socket head screw for attaching both the housing and the free end of the cable, and a socket wrench can be included with the standard device. The entire assembly is of 5 1/16 in. diameter.

When properly installed, the spring offers negligible resistance to extension of the tool but will positively retract it to the neutral position upon release. The device provides a minimum retracting force of 5.5 lb. and a maximum of 9.3 lb. through an 11-ft. total extension. Units have been fatigue tested over 200,000 cycles without failure.

These safety return units can be mounted quite



Device provides automatic cutting mechanism return.

simply on most tools. The unit can also be adapted to meet special requirements and for integration into original designs. (231)

Their free-piston engine may compete in the power field

The newly developed GM-14 free-piston engine has a vote of confidence from **General Motors** Research Staff engineers as a future contender in the commercial power field.

During the past few years GM has learned a lot about free-piston engines. The company is convinced of their many advantages and is cognizant of their problems and limitations.

A total of 25,000 hours of testing indicates that future development will improve the engine's power output, economy and reliability.

Since they began development work on this free-piston engine, the rated power output has been in-

creased by 25%. The life of all critical parts has been extended until a 4,500-hour test can be run with over 90% availability. The engine runs satisfactorily on heavy fuel, with absolutely clean exhaust.

GM-14 is a free-piston gasifier or generator primarily designed for ship propulsion or power station operation. It is rated at 1,250 gas hp and has a thermal efficiency of 43½%. Some of its development problems were essentially the same as those familiar to engineers working on high-output, conventional diesel engines.

GM have successfully run one free-piston engine on a range of fuels varying from 100 octane gasoline



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The need for stop baths and interbath rinses, normally required in many processes, is virtually eliminated because of a positive squeeze roller design.

A high-efficiency blower system and electrical heating ensure rapid drying in the machine. The Processor is perfect for newsreels, TV news on film, motion picture “rushes” in the field,—in all cases where speed plus quality are essential.

Write for literature and quotations.

SPECIFICATIONS

AUTOMATIC TRI-FILM PROCESSOR TYPE T246 Mk3

Size: 54" long, 22" wide, 51" high
 Weight: 400 lbs.
 Power Consumption: 5 KVA maximum single-phase: 110 volts, 45 amps, or according to customer requirements
 Process Capacity: 1 to 4 rolls 16 mm } length
 1 or 2 rolls 35 mm } to
 1 roll 70 mm } 400 ft.
 Rate of Processing: 1½, 3 or 6 ft. per min.
 Temperature-controlled solutions and dryer. Daylight operation except loading of film into magazine. Processes perforated or plain film.



PSC APPLIED RESEARCH LTD.

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 PLYMOUTH 5-3371

MEMBER : A. V. ROE CANADA LIMITED & THE HAWKER SIDDELEY GROUP

through the gasoline range, kerosene, diesel fuel, Bunker C and crude oil. In addition, it has been run on vegetable and animal oils, such as whale oil, cottonseed or peanut oil. The only noticeable effect on engine output under these test conditions is that the power output varies directly as the content of the fuel being used.

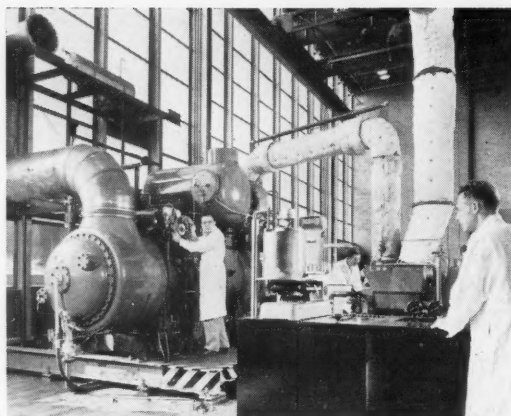
Early test work was done on several European models and at least eight major problems appeared during endurance runs. All were virtually overcome, either by design changes or by modifications to the lubricants.

Excessive cylinder wear was remedied by reviving surface finish specifications to comply with standard diesel practice. Wear, scuffing and breakage of piston rings were remedied by changing the facing and grooving the rings.

Bronze wear-bands on the pistons were discarded and special steel-backed, aluminum alloy bands substituted and grooved like the piston rings. The bronze bands had been subject to sulphur attack.

Early valve troubles were eliminated by making up valves with aluminum instead of steel segments, and valve blades were made of a suitable spring stock correctly processed for their ultimate use.

Other improvements were made in the design of



Free piston gasifier shown at the GM Technical Centre.

precombustion chambers, injector seals, tubes, connecting links and all sliding seal surfaces, to reduce oil leakage.

A smaller version of the free-piston engine is now being tested on the XP-500, the experimental passenger automobile. (232)

Oil with low carbon content and antigumming features



Clear evidence of the heat-resistant properties of No. 49.

The problem of oil carbon deposits in machines operating at high temperatures is no longer troublesome when a specialized lubricant developed by **Keystone Lubricating Co.** is used. This oil (known as No. 49 Light) resists oxidation, sludging and breakdown when subjected to severe laboratory and field tests. Its physical properties are listed in Table I.

Developed primarily for air compressor use, its low carbon content and antigumming features make it a superior lubricant for such applications as: ring bearings in electric motors, multiplate friction clutches, plastic molding heat transfer systems and so forth.

molding heat transfer systems, drying oven conveyor chains and textile tenter frames.

To determine carbon residue under heat, technicians tested Grade 49 with several other lubricants. They poured the oil onto watchglasses, baked them in thermostatically controlled ovens for 72 hr at 300 F and then checked the dishes for telltale carbon residues, an indication of how the oils will stand up in high temperature use.

Tests at maximum operating pressures have been made with air compressors and other machinery in hot, cold, wet and chemically contaminated atmospheres. In every case, the oil showed marked superiority over competitive oils. It demonstrated 500% longer usability, 66% savings in maintenance costs and 60% savings in oil consumption and substantial power savings.

TABLE

Physical Properties of Keystone No. 49 Light

Gravity Baume at 60 F	30.2
Flash Point	425 F
Fire Point	495 F
Vis. SUV at 100 F	368 sec
Vis. SUV at 130 F	190 sec
Vis. SUV at 210 F	56 sec
Viscosity index	96 sec
Pour point	minus 5 F
Cold test	minus 10 F
Carbon residue (Conradson)	0.33%
Corrosion ASTM	Negative
Slight oxid Value	6
SAE No.	30
Color number ASTM	6

(233)

TINNERMAN

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The flat-type Speed Nut from which has grown a family of over 6000 types and sizes of spring tension fasteners.

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DOMINION FASTENERS LIMITED, Hamilton, Ontario
a Geo. A. Tinnerman corporation





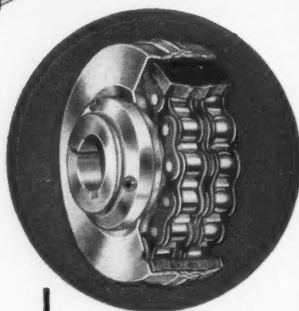
Immediate
delivery of
Acme
FLEXIBLE
COUPLINGS
eliminates
costly delays

Now you can get prompt service on precision, high capacity, Acme Flexible couplings, available in fractional to hundreds of horsepower ratings, direct from your Acme chain distributor.

Acme flexible couplings are used to connect two revolving shafts together, and to compensate for angular and parallel misalignment. Simple to install and disconnect by merely removing one pin.

Maximum capacity is obtained by distributing the load over all the coupling teeth.

An important plus is Acme's use of convex rollers which allow greater angular and radial misalignment. This is accomplished with a minimum amount of backlash. See your Acme distributor.



Each Acme coupling is complete with standard keyways and set screws. Grease retaining felt and snap-on cover can be furnished if required.



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ACME
for Service

Acme
Chain
Corporation

HOLYOKE
MASSACHUSETTS

Infrared ovens

(Continued from page 57)

been met. In some installations, it is also advisable to interlock the conveyor electrically with the heaters.

The radiant Calrod panels are mostly mounted on a slope. This design allows the heat to spread evenly across the section of the heating bank. For even better uniformity, the slope of the panels at the left-hand side should be set opposite to the slope at the right-hand side of the oven.

The space between the heating panels is closed by highly reflective baffles from electro-brightened, slightly anodized aluminum sheets. Usually it is not necessary to provide additional thermal insulation outside; this makes the oven less expensive and more flexible than convection ovens. It is, therefore, possible to have certain panel groups mounted on hinged frames.

The top, bottom and both ends of the oven should be closed in as much as possible to avoid heat losses by air drafts. In larger installations, recirculation of a portion of the exhausted air (and special air curtains at the entrance and exit of the oven) can be provided. If possible, the conveyor track (or belt) should be located in such a way that it is not exposed to direct radiation.

It is necessary to provide a certain air-drying period between the painting operation and the beginning of the heating process. This can easily be obtained by leaving enough space between the dip tank (or spray booth) and the oven; the necessary space depends on the conveyor speed, the type of paint and its method of application.

The paint on the parts does not usually harden until the parts have cooled down after baking. If the oven length and space limitations do not allow enough conveyor length for the cooling process, a fan can be used to speed up cooling.

Control Equipment

In most cases, with the exception of large installations, thermostatic control is not necessary, as long as the layout of the conveyorized far-infrared oven is based on sound design. It is usually sufficient to make the oven flexible, by grouping the various infrared panels in a number of circuits, and to operate each by means of an individual switch, in addition to the main switch which controls the whole oven. By selecting the various panel groups and switches according to various work sizes and gauges, considerable savings in electric power can be achieved. That is, by switching off the lower banks (for baking of short pieces) or by switching off several sections, for baking light parts. ★

Design Engineering Show

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P

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Revere Copper & Brass, Inc.	1635
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M. H. Rhodes, Inc.	636
Rigidized Metals Corporation	927

Continued overleaf

3

JOHN CRANE

"Pressed-In" SEALS

for economy, quick installation and life-long performance in all types of service

TYPE 11-A

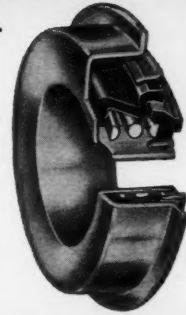
Synthetic Rubber Bellows • Small shafts to 3/4 in.

Services: hot or cold water, oil, gasoline, kerosene and other liquids non-injurious to synthetic rubber.

Pressures: up to 50 psi.

Temperatures: -65°F. to +220°F. Special construction to +300°F.

Construction Data: Packaged unit. Retainer does not contact shaft, permitting operation at a high rpm. One size can be used for several shaft sizes. Bellows encloses spring and metal parts to prevent contact with medium being sealed.



TYPE 6-A

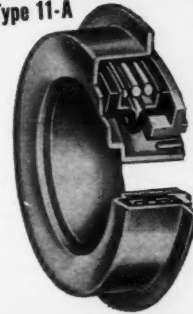
Synthetic Rubber Bellows • Interchangeable with Type 11-A

Services: hot or cold water, oil, gasoline, soapy and other liquids non-injurious to synthetic rubber.

Pressures: up to 75 psi.

Temperatures: -65°F. to +220°F. Special construction to +300°F.

Construction Data: Similar to Type 11-A. Does not contact shaft, permitting operation at high rpm. One size can be used for several shaft sizes. Spring and metal parts available in stainless steel or bronze.



TYPE 9-A

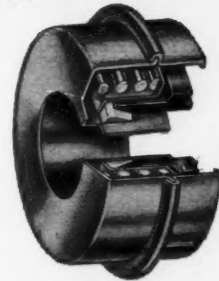
Sealing Members Made of Teflon* • Engineered for the particular application

Services: all chemicals, solvents, oils, corrosives and gases, hot or cold.

Pressures: to 150 psi. Balanced construction to 750 psi.

Temperatures: -120°F. to +500°F.

Construction Data: Packaged unit. Furnished in metallurgical specification best suited to the application. Chemically-inert Teflon wedge ring closely fits inner sleeve of retainer and is machine-mated to carbon sealing washer.



Contact "John Crane" for the particular seal best suited to your application. Request bulletin giving full information on "John Crane's" complete line of mechanical seals.

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JOHN CRANE

CRANE PACKING COMPANY



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NEW WONDER COATINGS FOR INDUSTRY FROM EPON* RESINS

- guard against corrosion
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- resist heat and chemicals

Surface coatings based on Epon resins withstand strong acids, lacquer solvents, hot concentrated sodium hydroxide, and concentrated liquid detergents. This chemical resistance is combined with outstanding adhesion to almost every type of substrate. Flexibility permits you to coat sheet material before forming.

Epon based finishes are scuff resistant. Take daily scrubbing and buffings on surfaces exposed to rough treatment.

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When ordering surface coatings, be sure to specify those based on Shell's Epon resins.

*Registered Trade Mark



EPON

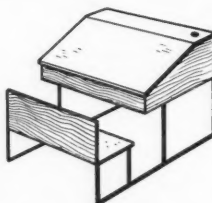
resins

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OF CANADA, LIMITED
Toronto Montreal Vancouver



Water tanks:

Coatings based on Epon resins are particularly suitable for tanks. Accidental denting of the outside of a tank will not cause a break in the lining.



Furniture:

Perfect for both indoor and outdoor furniture. Coatings insure great durability. Superior hard surface stands up to continuous scuffing, wear and tear.

Design Engineering Show

(Continued from page 81)

Riverside Alloy Metal Division,	
H. K. Porter Company, Inc.	1246
Rockford Clutch Division,	
Borg Warner Corp.	525
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Roehlen Engraving Works, Inc.	1128
Roller Bearing Company of America	933
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S

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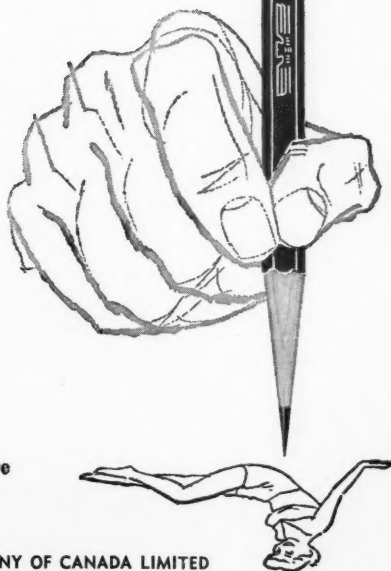
U

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Division	822
United States Rubber Company,	
Royallite Division	809, 811, 815

Continued on page 89



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"Electronic" is Eagle's trade name for a blend of crystal-line graphites of highest purity, reduced to particles of micronic fineness in our patented Attrition Mill. 100% "Electronic" graphite in every Turquoise lead gives you super-service in four important ways:

Super-Smoothness! Turquoise leads are smoother, faster. No harsh impurities slow your line or scratch the paper.

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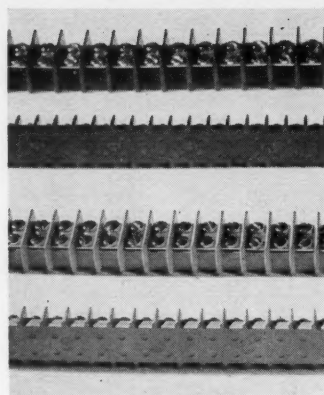
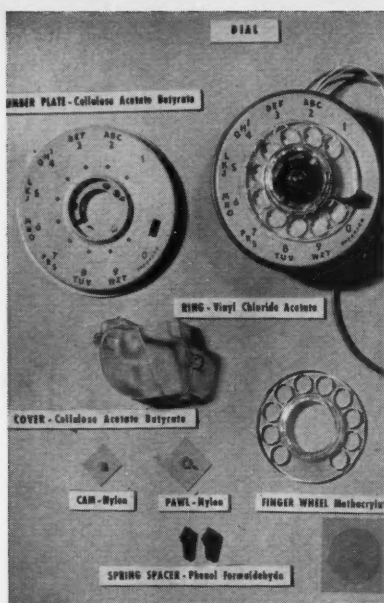
Super-Blackness! Because millions more of super-fine graphite particles are compacted in every inch of its lead, Turquoise deposits denser, blacker, more even lines that reproduce to perfection. c

Super-Grading! 17 individual, exactly controlled formulas of "Electronic" graphite and clay make 17 evenly spaced degrees that are uniform from end to end, from lead to lead, from year to year.

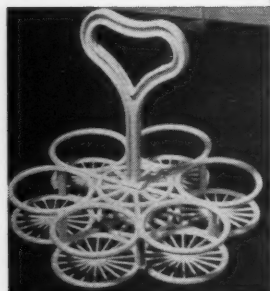
***"CHEMI-SEALED" (Super-Bonded)**
***EAGLE TURQUOISE**
DRAWING PENCILS AND LEADS

with 100% *"Electronic" Graphite

Telephone set parts ▶

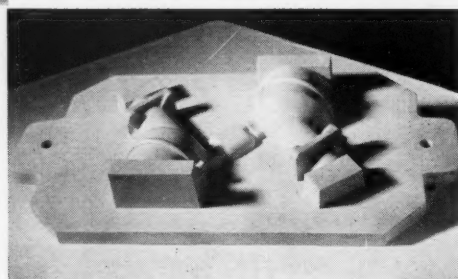


Phenolic resin terminal strips

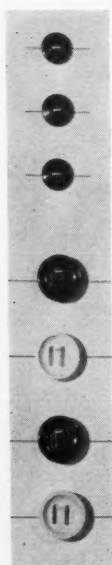


Glass tray: polystyrene

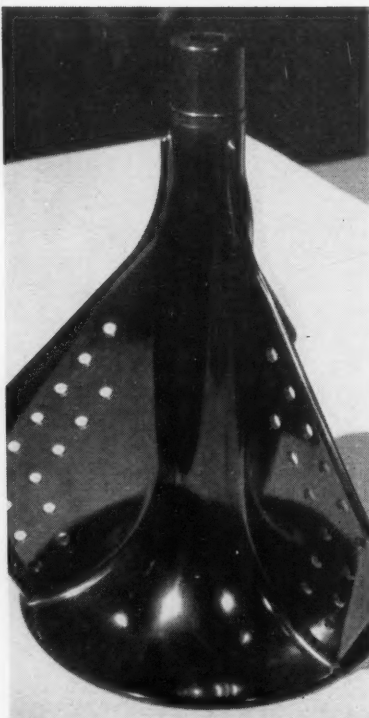
Seen at the SPI show in Ottawa



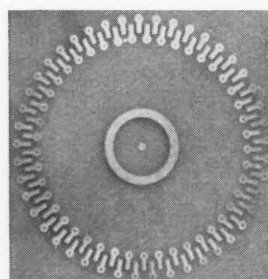
A foundry pattern in an epoxy



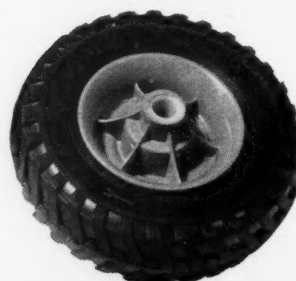
Buttons for the Arctic
from urea-formaldehyde



Phenol formaldehyde washing machine
part



This printed wiring was made
from an epoxy-glass laminate



Mower wheels from nylon
zytel

Society Column

International Union of Geodesy and Geophysics

More than 1,500 experts in the earth sciences will gather at Toronto on September 3-14 in connection with the XIth general assembly. Their main topic will be the International Geophysical Year (IGY) which starts in July. There will be delegates from 50 countries.

American Institute of Electrical Engineers:

The theme of the Northeastern district meeting (to be held May 1 to 3 in Pittsfield, Mass.) is: Engineering equals Industrial Revolution ($E = IR$). There will be sessions devoted to computers and data processing, plus industrial electronics and controls.

Society for Nondestructive Testing:

The second international conference on nondestructive testing (in conjunction with the seventeenth annual convention of SNT) will be held in Chicago, November 3 to 8. Theme of the conference: Nondestructive Testing Looks Ahead.

The conference is being held in cooperation with the second World Metallurgical Congress (sponsored by the ASM at its annual convention) and in conjunction with the National Metals Exposition. The latest materials, equipment and processes used in metal fabrication will be on display.

The American Material Handling Society:

Head of the committee responsible for the conference on material handling methods to be held in Montreal, September 30 to October 4 will be M. H. Engeland, Sherwin-Williams Co. of Canada, Ltd. Working with him will be a committee composed of fellow members of the Montreal Chapter of the AMHS, the sponsors of the Show and Conference.

Since the 1954 Show, there has been a tremendous development in material handling equipment and methods. This year's Show will give Canadian executives and material handling men an opportunity of keeping pace with the rapid developments.

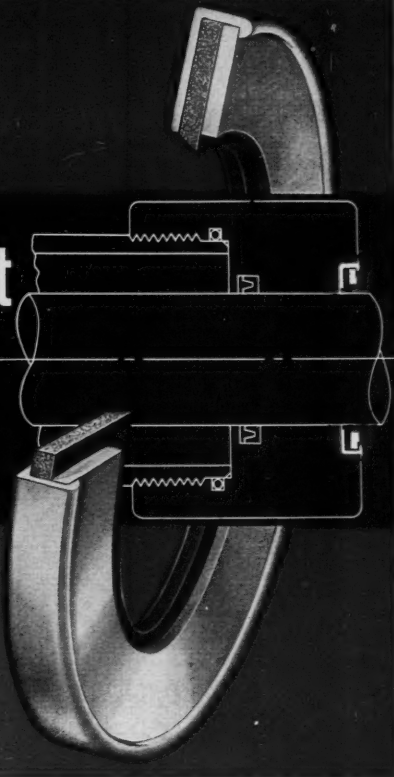
American Society for Metals:

On Friday May 3 there will be the annual "Stump the Experts" night. Presiding over the supreme court of metallurgy in his own inimitable way will be R. C. Stewart.

Chemical Institute of Canada:

The last meeting of the present season will take the form of a Smoker to be held May 7 at the War Amps Building.

Wipes out dirt
for life!



WEAR-SAVERS THAT WON'T STEAL POWER

Hydraulic cylinder makers use Chicago Rawhide's Type G wiper seals for many reasons. Here's one: the special Sirvis leather wiper element holds its own lubricant—operates at low friction. This means negligible power loss. Another advantage: the Sirvis leather element will not trap grit and carry it—will not score the shaft. Years of dependable performance have demonstrated the ability of C/R Type G Oil Seals to exclude dirt, dust and moisture. They may be the answer to your problem, too. Write for your copy of "C/R Perfect Oil Seals."



CHICAGO RAWHIDE MFG. CO. OF CANADA LIMITED

508 Wellington Street North
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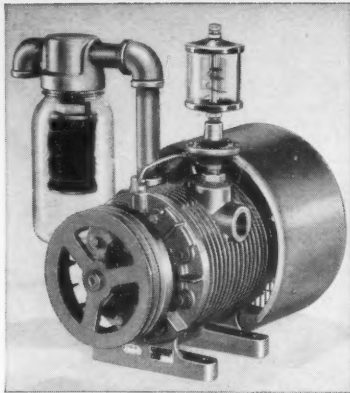
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Compressor Model 4565-P3 to 20 p.s.i.



Vacuum Pump Model 4565-V6 to 25" hg.

Big NEW 45 c.f.m. fan-cooled Model 4565 GAST AIR PUMPS— Twice the capacity of previous models!

COMPRESSOR

Delivers to 45 c.f.m., to 20 p.s.i.g. continuously with 5 h.p. motor at 1750 r.p.m. At lower pressures, 3 h.p. may be used. Includes automatic lubricator, felt type intake filter.

VACUUM PUMP

Delivers to 45 c.f.m., vacuum to 25 in. hg. with 3 h.p., 1750 r.p.m. For 35 c.f.m. at 1350 r.p.m., 2 to 3 h.p. is adequate. Has heavy-duty lubricator and exhaust muffler.

WRITE TODAY
for Bulletin
557-VP with
performance data.

Here's new, bigger-volume air pump utility—for original equipment or plant use! Built for continuous, heavy-duty service as either a Compressor or Vacuum Pump, the Model 4565 eliminates water-cooling headaches. It's air-cooled by a 10" diameter pitch fan enclosed by cowl-guard which directs cooling air and insures safety by covering fan mounted on shaft extension.

Long-lived, efficient 5-vane rotary design delivers a positive displacement of pulseless air. No air tank is needed on compressor.

Pump is easy to mount. Drive with double v-belts eliminates precision alignment problems, and fan on pulley adds extra cooling capacity. Heavy ball bearings, with double row on drive end. Pump weight approximately 92 lbs.

Investigate Gast Model 4565—it may solve a problem for you! Gast Manufacturing Corp., P.O. Box 117 Benton Harbor, Michigan.

SUGGESTED APPLICATIONS

As volume source of low pressure air or vacuum, independent of plant air lines. **COMPRESSOR:** For air atomizing No. 5 or 6 fuel oil on burners for packaged boilers to 500 h.p., etc. **VACUUM PUMP:** Does the work of two smaller pumps for paper or sheet feeding to printing presses, packaging, labeling or bottle-filling machinery. Suitable for pipe-line milking machines, and for vacuum-forming large plastic sheets. Recommended for dry vacuum only.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- AIR MOTORS
TO 4 H.P.
- COMPRESSORS
TO 30 P.S.I.
- VACUUM PUMPS
TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

Book Department

Machine Design by Joseph Edward Shigley (McGraw-Hill). The author has attempted to present an unusually scientific treatment of the subject and also to broaden the scope of machine design (as usually presented) by developing the relations between the design specification and the method of analysis (or synthesis) used in the solution. Particular attention is given throughout to development of latent creative ability in the reader. This is accomplished by emphasizing synthesis; by requiring the reader to make decisions and assumptions and to choose the method of analysis in solving the problems; and by emphasizing the deficiencies in present methods of design and analysis.

Tool Design by Cyril Donaldson and George H. LeCain (McGraw-Hill). General methods of tool design, that will enable the student to develop ideas into practical specifications for modern manufacturing methods, form the basis of this work. An attempt is made to broaden the basis of study as much as possible and for this reason topics that may be dealt with elsewhere (such as springs, welding and tolerances) are included in so far as they apply to tool design.

Modern Physics. A textbook for engineers, by Robert L. Sproull (Wiley). The impact of the modern physics of electrons, atoms and nuclei on the engineering sciences is forcefully demonstrated in such dramatic devices as the transistor and the nuclear power reactor. This book brings to the engineer a fund of knowledge necessary to the full understanding of many modern engineering processes and devices.

Mechanisms and Dynamics of Machinery by Hamilton H. Mabie and Fred W. Ocvirk (Wiley). This fresh treatment features a streamlined coverage of elementary subject matter. As a result, more space is available for the discussion of topics such as: analytical cam design, non-standard gearing, computing mechanisms and dynamic analysis of rotating and reciprocating machinery. Many examples are included and there is a generous selection of problems.

Theory of Flow and Fracture of Solids (Vol. 1) by A. L. Nadai (McGraw-Hill). This is the first of a two volume revision of Dr. Nadai's pioneering work, *Plasticity*. The previous edition contained a treatment of the plastic deformation of solids only but in this book the author has broadened the scope by surveying the general conditions causing fracture in materials. Also discussed are the results from a number of valuable experimental investigations of the yielding and fracture of ductile metals under combined stress.

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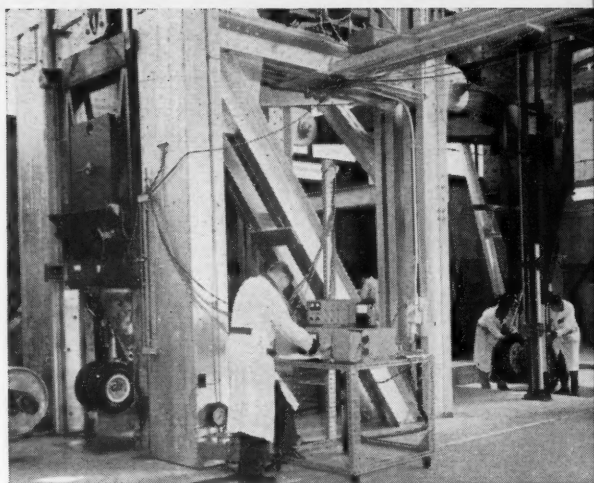
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Testing

This rig will test undercarriage performance



At left is the guillotine type rig for the smaller units. At right the parallelogram type for larger components.

Getting vital information on undercarriages takes time and patience

Richard T. Sewell DOWTY EQUIPMENT OF CANADA

The object of a drop test is primarily to find the dynamic performance characteristics of an undercarriage shock absorber-tire combination. Additional data may be gained during testing for analyzing the loads in the landing gear structure during landing.

There are two types of drop testing machine in common use: the vertical slide (or guillotine machine) and the horizontal parallel arm (or beam machine.) Most machines are of the first type because it is probably easier to construct, and is certainly more flexible in operation. The beam machine has the great advantage that the actual dropping area is completely unencumbered, and it is possibly less susceptible to vibration.

The vertical component of the airplane forward velocity (expressed as impact velocity on a drop test) is usually between 9 to 12 fps for most civil and military machines. For deck-landing naval airplanes, the impact velocity is increased up to 16 fps, while for V.T.O. airplanes (and helicopters) it may be as high as 25 fps to cater for an emergency engine-off autorotative descent.

The landing gear is fixed to the dropping head in the required attitude by means of suitable attachments. Space-geometry limitations usually preclude the use of actual airplane radius rods and drag/side stays, but these members may be replaced by suitable dummies. The dropping head is then loaded to bring the total weight up to the calculated static load on the gear (or a percentage of this in the case of non-airborne drop tests) and the head released from a height calculated to give the required impact velocity.

Nearly all drop tests are "non-airborne." That is, the falling weight is not supported at the moment of impact, and additional energy has to be absorbed by the shock absorber after impact. This is in direct contrast to the actual landing process, where the airplane is considered to be totally airborne (or at least 60% airborne) and there is little or no additional energy input after impact. In order to make the airborne energy absorp-

tion equal to the non-airborne energy absorption obtained on drop test, the falling weight in the latter case must be reduced to a value less than the calculated associated mass. The drop weight for a correct energy balance can be calculated from the predicted shock absorber and tire closures.

* Drag forces on a landing gear are imposed as a result of spinning-up the wheels, and side forces as a result of landing in a cross-wind. Both forces may be considered separately or compounded. These effects may be reproduced on test by dropping the gear on to a wedge (simple or compound), the tangent of the slope angle being equal to the required coefficient of friction between the tire and the ground.

It is becoming increasingly common to obtain drag effects on test by spinning the wheels up to the desired rotational speed immediately before impact. Since on test the drag forces are the result of stopping the wheels from spinning (as opposed to starting the wheels spinning during a landing), the wheels must be spun-up in the reverse direction.

The quantities most commonly measured during a drop test are: vertical mass travel, shock absorber closure (or vertical axle travel), tire closure and retardation. All these quantities are measured electrically, the first three by slide-wire potentiometers and the last by an accelerometer. The signals are amplified and fed into a multi-channel oscilloscope and the traces photographed by a continuous moving-film camera. The record can then be analyzed at leisure.

These four quantities are sufficient for an analysis of preliminary results during tests on a flat surface only (that is, vertical reaction only). During later tests it will, of course, be necessary to take recordings of drag and side loads, wheel speed during spinning and other transient phenomena. Strain gauges may also be fixed to the gear to determine the loads in the various members.

A drop test program on a landing gear may take many months to complete. It is only on rare occasions that the predicted damping orifices can be used without some alteration (the author knows of only one case). ★

Design Engineering Show (Continued from page 82)

United States Steel Corporation 1527, 1531, 1533
The United States Stoneware Co. 1229
U. S. Dept. of Commerce 114

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Valcor Engineering Corporation 808
Veeder-Root, Inc. 123

W

Waldes Kohinoor, Inc. 1010
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Industrial Division 1515
Whitney Chain Company 322
The Edwin L. Wiegand Co. 1525
Wittek Manufacturing Co. 1208

Y

The Yale & Towne Manufacturing Co.,
Powdered Metal Products Division 1226

Z

Zenith Electric Co. 1207

No time like the present

LOTS OF YOU ENGINEERS have the nucleus of an article tucked away in a drawer somewhere, either in the form of rough notes or as a rough typescript.

The reason, of course, that you haven't done anything about it is because you probably feel that nobody will be interested in publishing it—so why do all the work necessary to get it in shape for nothing?

There is somebody interested in your technical article: DESIGN ENGINEERING is always on the lookout for suitable contributions. Not that we are short of material, mind you. But it does seem a pity that good stuff should not see the light of day.

Why not act at once and tidy up that article, get it typed and submit it to DESIGN ENGINEERING? If we like it enough to publish it, you will be paid. Not a fortune, perhaps, but enough to make it worth your while.

And think of the personal satisfaction of seeing yourself in print.

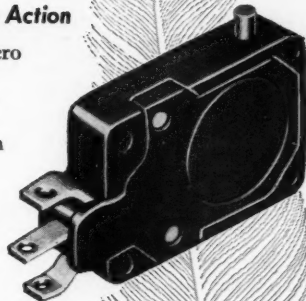
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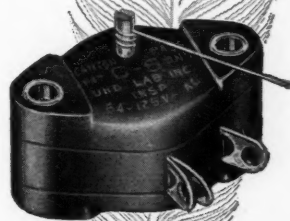
NEW MODEL CM Snap Action

The big features of this new, small Acro precision switch are long life and light operating pressure—lighter than any other switch of its type. Having snap action parts of beryllium copper and contacts of fine silver, the CM offers extremely good repeatability and will deliver millions of actuations *without failure*. It can be ganged for multi-pole applications, will operate in a temperature range of 160°F., and is designed for use where positive control is required and slow actuation inherent.



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Operation of the Acro CS switch is through rotary motion (either clockwise or counter-clockwise), with a spring bias provided for quick return. Available in normally open and normally closed models, this new switch also operates by very light pressure and will give extra long mechanical and electrical life. It's designed for use where rapid actuation is inherent and contacts are protected against vibration or shock in the "at rest" position.



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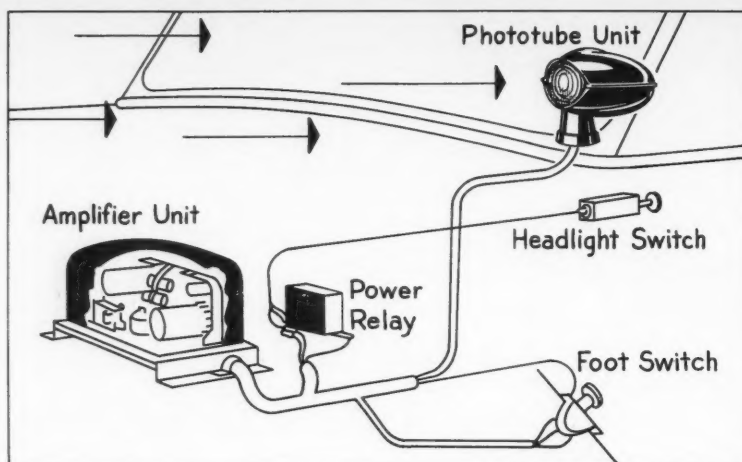
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The main components of the Autronic-Eye and their positioning in the car.

Special-assistant to the night drivers

It makes decisions (high or low beam?) for the man behind the wheel

By P. E. Biggar

If you have done much cross-country driving at night, you know what a nuisance the constant switching of the headlamp beams has become. How far away is the approaching car? When should you lower the beams? Then remember to raise them again. The mind is constantly at work making decisions. Night driving, especially in bad weather, becomes a constant strain. No wonder many drivers stay continually on the lower beam, a dangerous habit.

Four years ago the engineers of the Guide Lamp Division of General Motors came up with a solution. This is the Autronic-Eye, an electric device which has its light-sensing unit mounted on the car just inside the windshield. This unit receives light from the headlamps of approaching cars and, at the correct moment, automatically switches its own headlamps from upper to lower beam (or back again) according to the amount of light it receives.

The device is interesting, because it takes into consideration many factors and must come up with decisions that are acceptable both to its own driver and also to the driver of the other car. This is not an easy task. Here are some of the specifications that had to be met:

The device must react to a very small amount of light (this is because the light is received when the on-coming headlamps are still some distance away), must switch its own headlamps promptly to the high beam when the other car has passed. To do this, a stable multiplier phototube (a million times more sensitive than existing tubes) was perfected.

The device must hold its own lower beams when the approaching driver lowers his beams. To do this, the Autronic-Eye, when switching to the lower beam circuit, automatically increases its own sensitivity so as

to hold this circuit with only one-tenth as much light as that required to make the shift.

It must work correctly on winding roads, yet must not be misled or confused by roadside signs and so on. This is accomplished by masking, so as to limit the horizontal angle through which incoming light may reach the phototube. This angle is, of course, a compromise between conflicting requirements.

It must not be upset by glare from a wet road or reflection from fresh snow, or any reasonable fore-and-aft tilt of the car caused by load changes. This is accomplished by masking, to limit the vertical angle through which the incoming light may reach the tube.

Human assist

It must not be upset by fog or rain, or by dirt or ice on the windshield. It must hold the lower beam while warming up. It must not be damaged by daylight or thrown out of adjustment by normal voltage variations, by heat, cold, dust, vibration or moisture.

While the device does all these things automatically, it does require a little added direction in some circumstances.

For example, for city driving (or when following another car) the low beam may be held by the driver by pressing a foot switch. Another setting of the same overrule switch gives the upper beam for signalling or for driving in the dusk, when there is still too much light for the device to operate automatically.

So much for the rather formidable list of what the Autronic-Eye has to do; it remains briefly to describe the circuits by means of which all this is accomplished. Electrical energy for the circuits is, of course, obtained from the car's electrical system. This may be either at 6 or 12 volts and the circuit is connected through the headlamp switch.

The current for the Autronic-Eye circuit goes first

Continued on page 93)

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Autronic-Eye

(Continued from page 90)

to a vibrator, then to a transformer. The transformer has two secondary windings, one for an output at about 1,000 volts ac, the other for about 150 volts ac. The first is fed to a voltage control and through various resistors to a multiple phototube. The 150 volt circuit supplies power for operating an amplifier tube and also a sensitive relay. When little or no light is reaching the phototube "eye," the amplifier tube puts out enough current to close the relay. When sufficient light is reaching the phototube, a negative bias in the amplifier control grid works to reduce the current to the relay, causing it to open. This opening leaves a much larger resistance in the phototube circuit and causes the phototube to become about ten times as sensitive in the lower beam position as it was in the upper beam position.

With the foot-operated switch in the normal (automatic) position, current through the sensitive relay operates to open or close a 12 volt power relay, which in turn switches the headlamps to either the upper or lower beams. With the foot-operated switch in either of the two over-rule positions, current is fed directly to either the sensitive relay or the power relay, as required, to override the automatic control.

Referring now to the design of the phototube unit housing, a condensing lens (aimed directly forward) focuses incoming light through an amber filter and the rectangular opening in a mask onto the phototube. The purpose of the amber filter is to block off light toward the violet end of the spectrum and thus reduce the input of skylight and moonlight much more than that of incandescent light. The purpose of the mask (as already stated) is to define the vertical and horizontal angles through which incoming light is permitted to reach the phototube and thus prevent unwanted effects from reflected or roadside lights.

Since it is quite possible for the driver to leave his headlamps turned on in broad daylight (as, for example, when coming out of a tunnel), protective resistors are built into each diode circuit of the phototube. Also, since car battery voltages vary as much as 30%, a voltage regulator is necessary. This limits the variation in the headlamp dimming distance to a total range of less than 10%. The Autronic-Eye is designed to work on a maximum current consumption of only 1.4 amps, adding little to the load on the overworked car generator.

Here is an ingenious device to relieve the driver of a burdensome and tiring job and to make night driving safe. ★

Potter & Brumfield engineering is in this picture



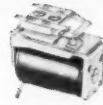
Which *P&B* relay would you specify to keep conversation going over a **MOBILE 2-WAY RADIO?**



MB Series



TS Series



MC Series

When one of America's leading manufacturers of electrical and electronic equipment began the design of a lightweight 2-way car radio, they were faced with several specific requirements in selection of relays. They had to be compact, light in weight and engineered to withstand the shock and vibration of off-the-road service. P&B engineering solved the problem with a modification of the TS series multiple switching relay.

In this application the TS relay has a dual personality. It connects the power supply unit to both the transmitter and the receiver. Power supply is controlled through the relay to either unit by the operator.

This is just another example of how P&B engineering is daily adapting standard types of relays or designing completely new types to meet specific requirements of new products. P&B's unique 25 years of engineering experience in relay applications is a source of quick, correct answers to your relay problems. Write today for new compact catalog.

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Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

See our catalog in Sweet's Product Design File.

ENGINEERING DATA

SERIES: TS. Miniature off-set springs telephone type.

CONTACTS: 5/64" dia. palladium (rated 3 amps.) 1/4" dia. pure silver (rated 5 amps.).

CONTACT ARRANGEMENTS: Up to 20 springs, maximum 10 in each stack, using any form combinations within max. limits.

VOLTAGE RANGE: DC: up to 220 V.
AC: up to 230 V. (4 poles).

COIL RESISTANCE: 30,000 ohms. Shaded coil available for 60 cycle operation up to 230 V. using 4.7 VA nominal.

POWER REQUIRED: 100 mw. per movable arm.

TEMPERATURE RANGE: Stack insulation of XXX phenolic spacers: -55° C. to +85° C. Glass malamine spacers: -55° C. to +125° C.

TERMINALS: Pierced solder lug holes for 2 No. 16 hook-up wires. Also available: Push-on taper tab connectors.

ENCLOSURES: Dust cover or hermetically sealed enclosures: Round: With octal plug (Max. of 8 springs) Rectangular: With octal plug; 4 to 14 pierced solder lugs; header to III 14-pin miniature relay socket; Multiple solder header 18 springs Max.

DIMENSIONS: (4 Form C) 1-19/32" L. x 1-1/16" W. x 1 1/2" H. (open) (4 Form C) 1 1/4" L. x 1-13/32" W. x 2-3/16" H. (Hermetically sealed) (6 Form C) 1-29/32" L. x 1-5/16" W. x 2-9/16" H. (Hermetically sealed).

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Letters

Readers' viewpoints . . .

Back issue wanted

You wrote to our Montreal office at 1261 Shearer Street, Montreal, and advised that Mr. D. G. MacKenzie, Consulting Engineer, Fernwood Farms, Ganges, B.C., was interested in a field telephone set which was described in your February 1956 issue of Design Engineering, page 55.

Unfortunately our copy of this issue has been misplaced. So that we may intelligently quote our customer may we have a copy of the February 1956 issue. from J. Martin, Manager, Telephone Sales, Northern Electric Company Ltd., Vancouver 3, B.C.

(A copy of the February issue of Design Engineering was forwarded to Northern Electric Co. Ltd.—Ed.)

Erector set

I have come across an article in the February issue of Design Engineering regarding Servoboard Kits. This was listed under your Ref. No. 213.

I would appreciate it if you would provide me with further literature on this subject.

from A. Fox, 2118 St. Catherine St. W., Montreal 25.

(We didn't have any literature on hand but gave him the name of Servo Corporation of America, New Hyde Park, New York.—Ed.)

Back issue wanted

I would appreciate it very much if you would kindly send me a tear sheet of the article "How Fast Can You Wrap a Stator Core," which appeared in your magazine, Design Engineering, June, 1956, page 63.

from O. R. Palomo, Product Engineer, International General Electric Co., 150 East 42nd St., New York 17.

(A copy of the June 1956 issue of Design Engineering was forwarded with our compliments—Ed.)

Wall chart

Kindly send one wall chart by Henning Bros.-Smith, article number 232 on page 66 of Design Engineering for March, 1957, for inclusion in our Engineering files.

from J. E. Fielder, Standards Sub-Unit, Electronic Equipment & Tube Dept., Canadian General Electric Co. Ltd., 830 Lansdowne Ave., Toronto, Ont.

(We wrote to explain that the charts are obtainable from Henning Bros.-Smith at 91-127 Scott Ave., Brooklyn 37, N.Y.)

Modular design

Please forward, marked for the writer's attention, New Products Literature Bulletin No. 207.

Your early response to this request will be greatly appreciated.

from C. S. Warwick, 900 Commonwealth Ave., Boston 15, Mass.

(Unfortunately, Mr. Warwick didn't state which month. When we wrote to point this out, it transpired that he was referring to January 1957, page 41 and the modular enclosure system made by Elgin Metalformers Corp., 630 Congdon Ave., Elgin, Ill.—Ed.)

Heat absorbent surfaces

In the January 1957 issue, page 52, an abstract of an article by A. D. Smith (Westinghouse) on heat absorbent surfaces is published.

Could you advise where a copy of the complete article is obtainable or where we could reach A. S. Smith?

from W. R. Moggridge, Chief Inspector, Plant 5, Ford Motor Company of Canada Limited, Windsor, Ontario.

(Our information was obtained from the Dow Corning Corporation, Midland, Mich., and this we told our enquirer.)

Reprints wanted

At your earliest convenience, kindly forward the undersigned two reprints of: "Those Versatile Devices—Thermistors," by Robert S. Goodyear, as published in Volume 3, No. 2, February, 1957 issue of Design Engineering.

from, Archie W. Judson, Jr., Instrumentation Supt., Minnesota and Ontario Paper Company, International Falls, Minnesota, U.S.A.

(Two copies were duly sent—Ed.)

Explosive rivets

In the June 1956 issue of Design Engineering, on page 52, there was an article on the use of Explosive Rivets. Would you please advise where I could write for more details and prices on this type of rivet.

from, G. Hall, Plant Engineer, The Wallace Barnes Co. Ltd., 274 Sherman Ave. North, Hamilton, Ont.

(We contacted Du Pont (Canada) Ltd. and asked them to send full details to Mr. Hall—Ed.)

Metal bonding

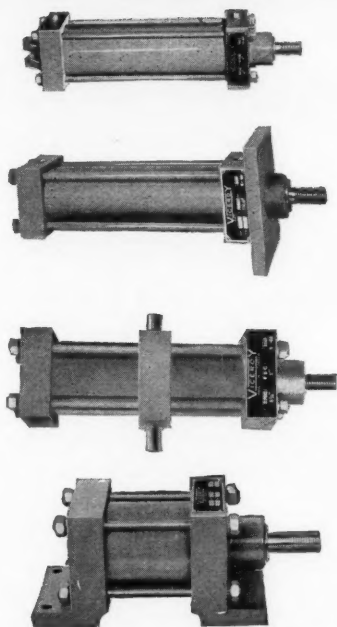
We plan to digest an article which you are featuring in Design Engineering, in a future issue of our magazine. The article has to do with metal bonding and was recently obtained by you from Avro Aircraft, Ltd. Could you give us the title please, the name of the author (if any), the volume, date of issue and page numbers?

from, D. F. Ritchie, Assistant Editor, Metal Progress, 7301 Euclid Ave., Cleveland 3, Ohio.

(This information we supplied—Ed.)

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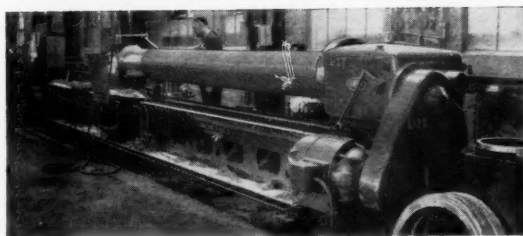
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New products

continued

Support stands

The line of chemical and physical support stands made by **Central Scientific Company** have been restyled to improve their appearance and efficiency for laboratory use.

The cast iron base (finished in attractive blue hammertone) gives weight where it is needed for greater stability. The stands come in the rectangular type (for chemistry) and the Harrington V-shape (for general physics). The rectangular bases have reinforced bottoms to prevent warping and both types are ground flat to eliminate wobble. (207)

Sound trap

A product is announced, designed and built in Canada for the specific purpose of solving the noise problems encountered in schools and auditoria, where halls and corridors are used for carrying return air. This type of system is the cheapest and one of the most satisfactory that can be used, but it has always suffered because hall noise passes through the return grilles and interferes with the activities of classroom or auditorium.

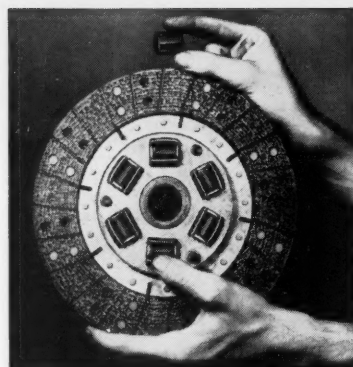
Model 100-48 **Winnett Boyd Ltd.** sound trap is thin enough to fit into a 20 in. wall and pass a flow of 1000 cfm at less than 0.04 in. of water. With the sound traps installed, return air grilles can open directly into the hallways. The trap is very effective in all the voice frequencies, producing an attenuation in excess of 20 decibels at 2000 cycles. It is 12 in. high, 29 in. in the direction of air flow, and of a width to suit particular needs. (208)

Rotary accelerator

A small and compact precision-built rotary accelerator, for calibrating and testing small assemblies by subjecting them to known values of acceleration, and for calibrating accelerometers, has recently been developed by **Schaevitz Machine Works**. This unit (Model C-1-A) is ideal when space is at a premium. It is capable of subjecting objects (weighing a maximum of 3 lb. each) to accelerations up to 250 g. (209)

Clutch plate

A replacement clutch plate, that uses resilient neoprene blocks and not conventional metal springs, is announced by **du Pont**. The neoprene elements smoothly absorb and transmit the torsional forces involved. Despite countless flexings and exposure to heat and



No chatter — no loose torsion springs.

oil, they retain their elasticity and outlast the clutch facings. These plates are available for most cars and trucks. (210)

Portable hand lamp

For safe yet practical lighting in flammable atmospheres (such as in the interiors of fuel tanks during cleaning or painting operations), **Crouse-Hinds Company of Canada** has just introduced an



Lamp body has heat-dissipating fins.

explosion-proof portable hand lamp (type EVH70). It weighs less than 11 lb. and uses 150 watt PAR-38 reflector type spot and flood lamps, to produce a concentrated light pattern. The fixture is UL-approved for Class I, Group C locations (atmospheres laden with flammable mixtures of ethyl-ether vapors, ethylene or cyclo-propane) or group D locations (atmospheres containing hazardous quantities of gasoline, hexane, naphtha, benzene, butane, propane and alcohol. (211)

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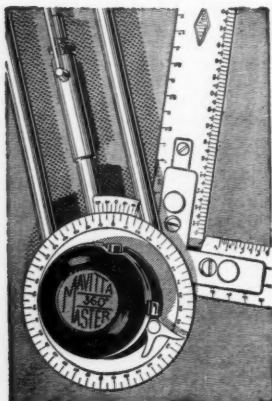
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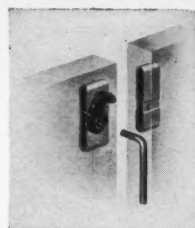
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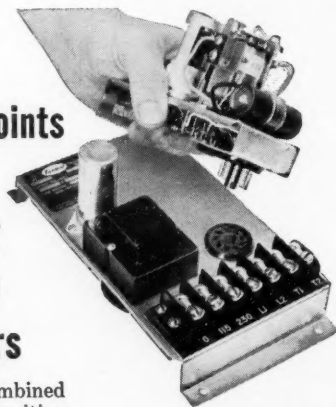
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Editorial

The Place of the Engineering Technician

A smart move has just been made by the Association of Professional Engineers of Ontario who are now in the process of certifying the estimated 30,000 engineering technicians.

Under the program (the first of its kind in Canada), engineering technicians who apply for certification will be examined by a special panel of examiners and certified in five grades, as determined by their educational qualifications and technical experience.

Such a system of certification will be of great value to employers and technicians alike. Under the program, engineering technicians will be given an opportunity to advance through the various grades up to Grade V. By further self-improvement, they could later become eligible for registration as professional engineers.

The program is the result of a study of the engineering technician problem by a special committee set up by the Association, headed by Dr. George B. Langford, P.Eng., Head of the Department of Geological Sciences, University of Toronto. Dr. Langford claims (and we heartily agree) that there is an urgent need for such a system of registration for technicians. It will, he added, encourage them to progress and also serve industry as a method of defining the upgrading of their technical employees, employment requirements and salary structure.

The Association will act as an examining body and will maintain a register of certified engineering technicians. A certificate will be issued stating that the person has been examined and granted a certificate as "engineering technician Grade . . ." and that this fact is recorded at the Association offices. The plan at the moment is experimental, says Dr. Langford, and certification is not compulsory.

When it is considered that everyone is complaining of the shortage of engineers, it is certainly a good move that the technician should receive recognition, thereby freeing the professional engineer for work that only he can perform.

Enquire within

It is an excellent idea to have an Information Centre at the Design Engineering Show (New York Coliseum, May 20 to 23). Located just inside the first-floor entrance (in Booth No. 437), it will be invaluable to the design engineer with only a limited time at his disposal.

The Centre will have detailed records of all the products on view and also of many other lines handled by exhibitors.

William Morse .



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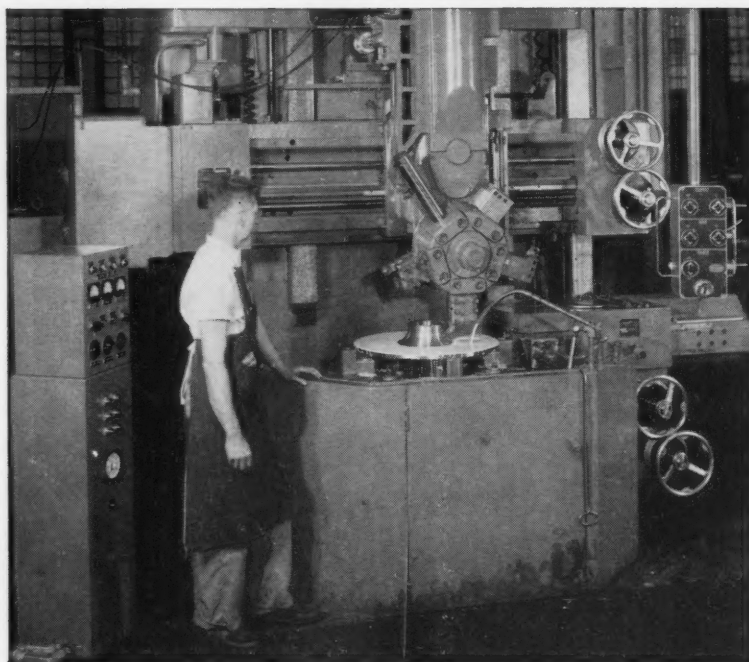
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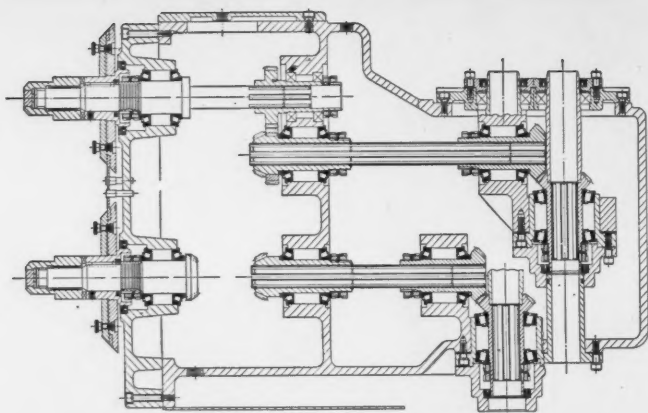


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